Cold Pack and Massage
in the
Treatment of Anæmia.

ON THE USE OF THE COLD PACK FOLLOWED BY MASSAGE IN THE TREATMENT OF ANÆMIA.

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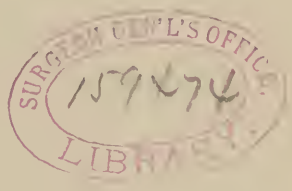

NEW YORK
G. P. PUTNAM'S SONS
182 Fifth Avenue
1880

With the

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ON THE USE OF THE COLD PACK FOLLOWED BY MASSAGE IN THE TREATMENT OF ANÆMIA.

I WAS led to use the cold pack in the treatment of spanæmia from the belief that it would tend to increase the rapidity of tissue metamorphosis; this would be expected to indirectly increase assimilation, and therefore promote absorption of nutritive material from the digestive canal. To test the correctness of this hypothesis, I analyzed the urine elaborated during the pack and passed immediately after, and compared its composition with that of urine excreted during other portions of the same day. The first conspicuous result of these analyses, was the demonstration of a marked increase in the elimination of urea during the hours of the pack. From this fact I at first inferred that my hypothesis was justified, and that the characteristic effect of the pack was to accelerate tissue metamorphosis—to increase waste and the products of oxidation — thus indirectly promoting assimilation. But closer examination of the facts showed that this conclusion was too general, and that the real influence of the pack both permitted and demanded a more minute analysis.

I regret very much that circumstances prevented me from combining these analyses of urine with the analysis of the blood by means of the hematimetre. This will be done in another series of cases. In these, the modifications of

the anæmic condition were estimated by the ordinary clinical tests.

When the urine was analyzed, the urea was estimated by Liebig's volumetric tests. In two clinical and two experimental cases, the analysis of the urine was carried farther, and a quantitative estimate obtained of the inorganic salts and of the organic material other than urea, including uric acid, and the substances sometimes classed together as "extractive." The method for obtaining the quantitative estimate of the latter, was adapted from Neubauer and Vogel, pp. 149, 150.*

In the three final cases no examination of urine was made, but the cases are recorded for the sake of the clinical results.

CASE 1.—Miss A. B., æt. 21, first seen May 8, 1878. Then in a profoundly anæmic condition ; weighed only 78 lbs., and was so feeble that she could with great difficulty mount the stairs, or even walk on level ground. The anæmia seemed to have initiated in repeated attacks of malarial fever. At first, menstruation had been very profuse, and recurred every three weeks ; this, doubtless, contributing to the anæmia in which the menorrhagia origin-

* The entire weight of the solid constituents of the urine was first calculated from the specific gravity carried out to four decimal points. The above calculation is for 1,000 c.c. ; from it a calculation is easily made for 10 c.c. The amount of urea in 10 c.c. of urine was then ascertained by Liebig's test. Another specimen of 10 c.c. was evaporated to dryness over a water-bath, in a small, accurately-weighed, fine porcelain capsule with a close cover. This capsule was then placed on a triangle and heated until all the organic matter of its contents had been completely carbonized. Boiling water was then poured upon the contents of the capsule ; allowed to stand a little while and then filtered off through a weighed filter ; and this process repeated (the same filter always being used) until the carbonaceous mass was entirely freed from the soluble salts. The filter was then returned to the capsule, the latter covered, and with its contents cautiously raised to red heat, when the entire carbonaceous mass was consumed and disappeared. To the same capsule was now returned the solution of salts ; this evaporated to dryness ; the residue heated to red heat for a moment ; the capsule cooled over sulphuric acid and weighed. After deducting the weight of the capsule and of the ashes of the filter previously estimated, we thus obtained the weight of inorganic salts in 10 c.c. of urea.

This weight was deducted from the total amount of solids calculated from the specific gravity ; the residue was the organic matter in 10 c.c. From this was again deducted the amount of urea estimated volumetrically ; the residue was the extractive.

These amounts thus ascertained for 10 c.c. were calculated for the whole amount of urine analyzed.

ated. For eleven months there had been complete amenorrhœa. The patient had suffered for years from constipation, but during the last year this had become excessive ; on account of it the patient had been several times treated by drastic purgatives, with the effect of making her condition worse. For about nine months the constipation had been complicated with a "membranous colitis." There were frequent discharges of the characteristic mucous membrane from the bowels ; on one occasion, after a colocynth pill, this membrane was tubular, and measured three-fourths of a yard. Associated with this was marked tenderness on pressure over the left end of the transverse colon and over the entire descending colon. The anorexia was extreme. There was much sleeplessness and nervous irritability ; a good deal of spinal tenderness to pressure existed. There was absence of respiratory murmur ; prolonged expiration and dulness at the apex of the left lung.

The treatment was at first directed toward the relief of the obstinate constipation and (probably) passive hyperæmia of the colon. The patient was directed to take cold water enemata, from 2 quarts to a gallon in quantity daily. A grain of tartate of iron and potassa was given every hour, together with minute doses of powdered ipecac. To avoid irritation of the intestine, and to secure nourishment by stomach absorption, the patient was placed upon milk diet and soups, containing a fixed quantity of Leube's extract. Of this, during the first fortnight, she took only a tablespoonful a day, together with one quart of milk.

On June 11th there was already considerable improvement. The enemata procured regular evacuations, in which were only shreds of mucus. The tenderness over the colon, also that on the spine, was quite gone ; the sleep was much better. On this day, while insisting on an increase in the food, the cold pack was first ordered, together with entire rest in bed. The pack was to be taken every other day, to last an hour, and to be followed by massage. The patient was to be enveloped first in the wet sheet, this surrounded by a dry one, and that by six blankets, the whole drawn tightly around her body.

As the patient lived at some distance, the massage was performed by a woman procured from a bathing establishment, and, as I had reason subsequently to believe, the rubbing was quite ineffectually administered. The benefit derived from the combined treatment was therefore much more attributable to the pack.

On June 22d the patient reported that she was always very much

tired on the day of the pack, but "felt splendidly" the next day. At this date was taking two quarts of milk besides the Leube's extract, and felt a desire for ordinary food, as she had not done for 18 months. Weighed 84 lbs.,—gain of 6 lbs. since beginning of treatment, and of 2½ lbs. in the week following the pack and rest in bed.

The patient stayed in bed for three months from June 11th, receiving the packs every other day, and continuing the rest of the treatment, upon whose details it is not necessary to dwell.

Mixed diet was resumed on July 4th, but after an attack of diarrhœa a temporary return was made to the milk. The cold water enemata were replaced by enemata of lime water.

On September 9th, patient still required enemata, and there was occasionally some mucus in the stools, but she announced herself as feeling "perfectly well." Had a good appetite, slept well, had no pains. Weighed 93 pounds, face full and colored. At this time perspired freely in packs. From this date packs and rests in bed were given up; enemata replaced by small doses of tamar indien; the iron and ipecac continued. The improvement in strength was so rapid that in a short time the patient could walk several miles. Menstruation recurred a year later. The patient has continued not only well but, to her own view, robust—certainly active, rosy, and stout enough for her age. The induration or collapse at the apex of the right lung entirely disappeared.

In this severe case the complexity of the treatment adopted makes it a little difficult to estimate the precise share attributable to the pack. The prolonged rest in bed might by some persons be credited with the largest share in the recovery, since the essay of Weir Mitchell has so widely popularized the idea of rest in the treatment of anæmia. I think myself, however, that this rest was of the least consequence in the case. The girl never had been overworked in any way, hence the etiology of her anæmia was entirely different from those in which rest is so beneficial; moreover, owing to her great debility, this patient had been in a state of nearly complete repose for two or three months before I saw her, from incapacity to choose otherwise. Yet her condition steadily deteriorated; she was wasting away from slow starvation.

In regard to the massage, I have reason to believe that it was not energetic enough to affect the muscles; its influence was probably confined to the skin. The iron was unquestionably of importance; but, before the course of treatment above indicated, the patient had frequently taken iron without benefit. Finally

the enemata may be supposed to have powerfully affected the circulation of the intestine, and to have acted synergistically with the cold pack in promoting absorption.

Case 2.—Miss C. D., young lady of 25, profound anæmia with amenorrhœa, obstinate constipation, resisting purgatives, as podophyllin and castor oil, which were often employed. Two years before the first consultation, patient had had an attack of scarlatina. After this, failed to menstruate for six months, then menstruated throughout the winter for another period of six months, then the menstruation ceased again and had been absent for a year. Associated with the obstinate constipation, was atonic dyspepsia ; and as a result of both the anæmia and the digestive disturbances it caused, the patient suffered from abundant acne simplex, which covered the face with comedones.

She was ordered to take a grain of tartate of iron and potassa every hour : daily enemata of two quarts of cold water each : diet of milk and Leube's extract, and the cold pack followed by massage every day. As a further corrective of the intestinal anæmia, belladonna tincture was given, gtt. v every three hours.

The patient soon found that the combination of iron and belladonna, when taken with the large enemeta, sufficed to obviate the constipation ; but that either of the three remedies alone was quite insufficient. The treatment was begun about October 1, 1878.

On December 20th, reported considerable improvement. The amount of food had not exceeded one quart of milk and nine tablespoonfuls of Leube's extract a day ; but this seemed to be sufficient, at least for the conscious wants of the patient. There was no more distress after eating, nor pain in the stomach or bowels. The acne had improved, the face was less swollen, less blackened with comedones, of which there were, however, still an undesirable abundance. The patient at the beginning of the treatment had been thin ; but now, although feeling stronger, had become still thinner. The treatment was continued, but the enemata were reduced to a pint, which was now found to be sufficient, while the belladonna and iron were taken regularly. Meat was allowed once a day. On June 12, 1879, reported again. While above régime was followed strictly, remained quite free from dyspepsia ; with the least variation from it, however, food lay heavy and undigested in the stomach. The acne had nearly disappeared.

The patient went to Europe in this month, and stayed until

November. During this time all treatment was interrupted. Far from benefiting from the journey, she suffered throughout intensely from dyspepsia, and had several severe hysterical attacks. In January of the present year came to New York again for systematic treatment. Cod liver oil was now added to the iron and belladonna. The cold packs were resumed, with massage much more energetic than she had previously been able to obtain in her own home. On being removed from the pack, each part of the body was rubbed with cold salt water previous to massage. After the pack and massage would always feel "furiously hungry." An effort was now made for the first time to reëstablish menstruation by means of local irritation of the endometrium. For this purpose, at first, the anode of a galvanic battery was carried to the fundus of the uterus, and held there for a few minutes while a current was passed, just perceptible to the hand of the patient grasping the cathode. This application was repeated every day for a week, causing each time a slight oozing of blood, such as was never caused by the simple introduction of a steel dilator. A month later, the general treatment having been continued with marked benefit to both dyspeptic and hysterical symptoms, an application of iodine to the endometrium was substituted for the positive current of electricity. On the day following this application a menstrual flow set in, for the first time in three years, and lasted abundantly for four or five days. The patient was feeling extremely well and able to eat an ordinary mixed diet. She then returned to her home, with directions to continue the general treatment, and to return to New York for the local application in case the menstruation failed to return spontaneously. In due time she wrote to say that it had done so.

As in the first case the treatment adopted was complex. The hydro-therapic treatment was reënforced by the administration of cod liver oil during the last and most successful months, and by the local irritation of the endometrium, which seemed to be the immediate antecedent of menstruation.

In regard to the iron, however, the patient had made abundant trial of it before coming to me, but had never seemed to derive any benefit from it; dreaded it as tending to increase the constipation.

The hourly administration of small doses of iron, with a view to saturating the hematoblasts,* was suggested to me

* Term given by Hayem to young, imperfectly developed corpuscles, not yet supplied with a normal amount of hæmoglobin.

by the well-known success of an analogous method in diphtheria, where the iron seems to act, in part at least, by averting a fatal impoverishment of the blood in its corpuscles.

In Case 3, the treatment was simpler, but followed by rapid and even surprising success.

CASE 3.—Miss E. F., æt. 16. Intense anæmia, with loud venous humming; pallor of skin and mucous membranes; various points of myalgia and of spinal tenderness; anorexia, great debility, constant headache, sleeplessness. First menstruation had appeared a year previous to date, then once again, four months later; since then there had been complete amenorrhœa. The patient was ordered a grain of tartrate of iron and potassa every hour, a cold pack and vigorous massage every day.

She reacted very well in the packs from the beginning; perspiring in an hour and a-half, an unusual circumstance with these profoundly anæmic patients. At the end of a week, there was already marked improvement, much less headache, some return of appetite and of strength; sleep sound and refreshing, pains gone. At the end of a month patient menstruated spontaneously. The double treatment was continued for a month longer, then the packs were interrupted, the iron continued. The patient has since remained perfectly well, during a period of six months.

In Case 3 the urine was analyzed for urea, partially before and after the pack.

CASE 4.—Miss G. H., æt. 35, anæmia of long standing, general, and also markedly cerebral, resulting in violent headaches. Much spinal tenderness existed. This patient had been much overworked, and in accordance with the indication furnished by this etiology, she was kept in bed during the duration of treatment, which lasted about six weeks and consisted exclusively in packs and massage. The patient's capacity for bearing the packs was very irregular, so that their mode of administration was obliged to be varied. Sometimes, instead of receiving a cold pack, she was, previous to the massage, enveloped in blankets for an hour, and then sponged off with cold water.

During the first week the patient received the cold pack for an hour daily; at the end of this time there was some increase of appetite, and the spinal tenderness was much diminished. The

estimations of urea were, through some misunderstanding, only begun on the seventh day of the treatment (December 28th), then, as seen by reference to Table I, the amount of urine was increased, the amount of urea lessened. From this date, however, the daily elimination of urea rose for a week, up to the day of menstruation when the packs were interrupted. This rise was associated with an increase in the amount of urine, but not exactly proportionate. (See Table I, January 3d to 9th.) The urea scarcely fell until the occurrence of a violent headache, on the third day of menstruation, interfering with ingestion of food.

Cold pack was resumed on January 15th, and then, for the first time, the urine was collected just after the pack (the bladder having been emptied immediately before it), and its composition compared with that of urine excreted at other hours of the same day. Reference to Table I (January 15th) will show :

1st. That the amount of urea eliminated both after the cold and after the blanket packs exceeded the hourly amount of an average day without treatment. (Compare December 21st.)

CASE IV.—TABLE I.

Date.	Form of Pack	Amt. urine in oz.	Amt. urea in grms.	Per hour, urine.	Per hour, urea.
Dec. 21st	Before treatment.	35	19.404		.808
" 28th	Day including pack.	56	15.719		
Jan. 3d	" " "	36	19.678		
" 4th	" " "	50	24.375		
" 5th	" " "	46	24.144		
" 7th	" " "	49	23.887		
" 8th	" " "	58	24.559		
" 9th	Menstruation, interrupting pack.	60	22.160		
" 10th	"	41	23.622		
" 11th	"	48	24.514		
" 12th	Headache for 24 hours	48	15.046		
" 14th	Headache continues.	50	21.421		
" 15th	Cold pack 1 hour, then Blankets 2 hours.		4.5132		1.4995 [cold pack]
" 24th	For entire day incl. pack.		18.730		1.506 [blankets] 0.677 [rest of day]
	Blanket pack, then cold sponging 3 hours		4.284		1.714—
" 25th	For entire day,		24.528		0.964 [rest of day]
	Blanket pack and cold sponging 3 hours.		3.058		1.019
" 26th	For entire day,		32.563		1.405 [rest of day]
	Blanket pack and cold sponging 3 hours.		3.187		1.062
" 29th	For entire day,		25.153		1.046 [rest of day]
	Blanket pack and cold sponging 3 hours.		3.058		1.019
" 30th	For entire day,		19.795		0.707 [rest of day]
	Blanket pack and cold sponging 3 hours.		1.512		0.504
Feb. 7th	For entire day,		17.850		0.778 [rest of day]
	Partial [abd.] cold pack 3 hours.		4.136		1.375
" 9th	For entire day.		18.479		0.683 [rest of day]
	Partial pack 2 hours.		2.068		1.034
	For entire day.		16.324		0.648 [rest of day]

2d. That the hourly amount for the rest of the day fell below this average amount, but only about one-fifth as much as the excess was above it.

3d. That the hourly amounts of urea eliminated during the cold and the blanket packs, were sensibly the same.

The patient continued to improve until the 24th, when she felt unusually well. A blanket pack, followed by sponging, was then substituted for the cold pack, in which she did not react sufficiently.

The 24th, day of maximum *bien être*, was also the day of maximum elimination of urea. On the 25th the amount of urea diminished after the pack was diminished; that for the rest of the day was increased, so that the amount during the two periods approximated. This approximation continued during the following days until the 29th, and coincidently, the patient ceased to feel so well; had more headache, less appetite.

On the 30th (see table) the urea eliminated during the pack fell even below that for the rest of the day; in other words, the patient *ceased to respond, by the characteristic phenomenon, to the pack.*

On the following day intense headache and nausea developed in the pack, which was therefore interrupted. On the same day menstruation recurred.

This was the first case in which it was made evident that *the diminution of urea during the hours following the packs is as important an element of reaction as is the increased elimination during the pack.* Any alteration of this sequence is followed by symptoms of malaise, of which the deviation from rule may be the cause of the consequence.

After menstruation, treatment was resumed by means of the partial pack, *i.e.*, the wet sheet was wound around the trunk of the patient only. The table (Feb. 7th and 9th) shows that increased excretion of urea still occurs; but the increase is not as marked as with the full pack when reaction is well established.

At this point the treatment was obliged to be interrupted, as the patient left the city. At the time of leaving she did not feel as well as in the middle of January, and about a fortnight later she wrote that she "began to feel the bene-

fit of the treatment." That is to say, returning to precisely the same set of conditions as she had been among previously, she found herself decidedly stronger, with less headache and backache and more appetite.

As regards the immediate effects of the packs, may be noticed :

1st. The highest elimination of urea took place, not during a cold pack, as we had expected, but during a blanket pack, followed by simple cold sponging (1.703 grms. per hour, Jan. 24th).

2d. The next highest elimination was on the *first day* of the general cold pack (1.499 grms., Jan. 15). The patient being then placed in blankets for two hours, the amount of urea per hour was almost the same (1.506 grms.).

3d. The third highest elimination is on Feb. 8th, *first day* of partial cold pack (1.300 grms.).

4th. After a few days of either method in this patient, the amount of urea eliminated during the pack falls, and at the same time various symptoms of *malaise* occur, often beginning in the pack, and continuing to increase, sometimes to violence, after it.

5th. The influence of headache in reducing the elimination of urea seemed to depend on the anorexia, sometimes absolute, which accompanied the headache, and prevented the patient from eating for many hours.

The examinations for urea in this case, and the more complete analysis of the urine made later, were first done by myself, afterward by my friend, Dr. V. A. White, who submitted to a special preparation for the work.

Case 5.—Mrs. J. K., an anæmic woman, æt. 41, with moderate sub-involution of the uterus (canal measures 8½ cm.). But possibly from some areolar hyperplasia, still more from the general anæmia, there had been absence of menstrual flow for two or three years, this being replaced by slightly sanguinolent leucorrhœal discharge at the menstrual epoch. This was preceded for a week

by feeling of general nervous distress, and said to be attended by sufficient prostration to keep patient in bed for three days. The anæmia seemed to have originated in profuse lactation. Multiple vaso-motor disturbances, chills, flushes, ringing in ears, etc. Frequent diarrhœa, attended from time to time with discharges of membrane (membranous colitis, as in Case 1); appetite fair.

The packs and massage were recommended for the anæmia, and to equalize the abdominal circulation. Large cold enemata were ordered for the colitis; dialyzed iron every three hours; koumyss; general faradization at menstrual period as a stimulant.

This patient was never able to bear the prolonged cold pack. In 15 minutes she began to be cold, and if the pack was maintained remained cold in it, and chilly throughout the day.

This peculiarity seemed to be connected with the chronic hyperæmia of the colon, causing, this time, not constipation, but diarrhœa. This morbid condition is so far analogous to the physiological states of digestion and of menstruation, that with the dilatation of a large section of abdominal blood-vessels, the dilatation of cutaneous blood-vessels, necessary for reaction to the cold pack, is often rendered

CASE V.—TABLE II.

Urea on five days without treatment of 1st month.

Date.	Amount in grms.	per ct.	Amt. per hour in grms.	Amt. urine per hour in c. c.	
Oct. 7th	23.76	3.3	0.990	30.00	
" 8th	24.60	3.5	1.025	30.00	
" 13th	22.88	2.6	0.953	37.66	average urea per hour =1.011
" 17th	19.00	2.	0.791	39.58	
" 20th	31.20	2.6	1.300	56.00	
Total	121.44		5.059		

Urea on five days without treatment of 2d month.

Date.	Amount in grms.	per ct.	Amt. per hour in grms.	Amt. urine per hour in c. c.	
Nov. 1st	24.876	2.5	1.024	42.699	
" 3d	30.819	2.5	1.284	51.574	
" 10th	29.614	2.4	1.234	51.453	average urea per hour =1.272
" 12th	37.208	3.2	1.550	48.449	
" 19th	30.546	2.4	1.272	53.032	
Total	152.763		6.364		

Urea of 24 hours including pack and massage.

Date.	Amount in grms.	per ct.	Amt. per hour in grms.	Amt. urine per hour in c. c.	
Oct. 11th	20.00	2.5	0.833	33.33	average per hour amt.=0.856.
" 24th	28.157	2.2	1.192	50.41	
Nov. 5th	31.180		1.299	52.577	
" 8th	26.532		0.110	48.42	
Nov. 13th	6.648	2.5	1.899	75.97	urea after blanket pack and massage $3\frac{1}{2}$ hours.
" 14th	5.961	1.7	1.987	116.895	5. mins. cold, then blanket and massage, Average 3 hours =2.029
" 15th	6.695	2.8	2.202	78.640	
" 18th	1.92	2.4	1.92	80.00	massage 1 hour without pack.
Oct. 31st	$\frac{3}{4}$ hour urine 1.68	2.4	2.24	70.00	Faradiz. $\frac{1}{2}$ hour during menstruation. Average per hour =1.023
Nov. 22d	$\frac{3}{4}$ hour 1.955	2.3	1.564	85.00	
" 23d	For $2\frac{1}{2}$ hours. 3.60	3.	0.144	120.00	
" 26th	For $2\frac{1}{2}$ hours 3.10	3.1	0.154	100.00	
Total					

Urea after pack 20 minutes—massage to 1½ hours.

Date.	Amount in grms.	per ct.	Amt. per hour in grms.	Amt. urine per hour in c. c.	
Nov. 4th (Before see N. 3d)	3.406	1.	2.27	227.170	
		(2.5)	(1.284)	(51.574)	
Nov. 5th (Before pack)	3.22	2.3	1.84	80.00	
		2.7	(1.165)	(43.148)	
Nov. 7th	2.40	1.2	1.600	133.32	
Nov. 8th (Before pack)		2.5	(1.091)	(43.68)	Average urea per hour =1.928
(After pack)	1.28	1.1	1.32	120.00	
Nov. 10th (Before pack)		2.4	(1.272)	55.032	
Nov. 11th (After pack)	3.92	1.4	2.613	186.66	
Total for hours of pack.			9.643		

difficult or impossible. On one occasion only was the patient in the pack three-quarters of an hour; on all others the pack only lasted fifteen or twenty minutes; or, finally, toward the close of the term of treatment, only five minutes; and was then followed by a blanket pack. The cold salt water sponging or slapping, and the massage, followed during an hour as usual.

The urine was only analyzed for urea, but it may be interesting to compare the percentage and amount of this under the several different sets of conditions indicated.

The summary of Table II shows:

1st. Although the cold pack, when given, only lasted ten to twenty minutes, the increase in the amout of urine and of urea eliminated during the hour and a half which included this pack and massage, was as decided as in the cases where the pack lasted one or two hours.

2d. The same increase was observed after a warm blanket pack followed by massage. The increase was most marked when this blanket pack had been preceded by five minutes cold pack. On this day (November 14th) the amount of urea per hour was higher (2.202 grms.) than on any day but two of the hours of packs (November 4th, 2.27 grms.; November 11th, 2.613 grms.). But it is noticeable that after the cold pack the amount of urine was very much increased (227.170 c.c., November 4th; 186.66 c.c., November 11th), so that the percentage of urea was low (one per cent.); while after the blanket pack of November 15th the amount of urine was much less, yet the amount of urea almost as high.

3d. An increased elimination of urea was observed after an hour of massage alone. Thus, 1.92 grms. on November 18th, as compared with 1.272 grms. of November 19th, without treatment.

4th. On the first day of general faradization (October 31st) the elimination of urea during an hour was increased; but the amount was not high on the subsequent days.

The average per hour for the four séances was less than for a similar period on days without treatment. This fact is interesting, as showing that cutaneous irritation alone, unless accompanied by some agency affecting the abdominal circulation, does not increase the elimination of urea.

5th. The estimate of averages is liable to be misleading, because the daily fluctuations in the elimination of urea are so great that it is only safe to compare the hours of the pack with the hours from the adjacent period, either just before or just after. Still it may be worth while to notice that on comparing the hourly elimination in periods of five days we find an average for:

Days without treatment, first month. Per hour.	Days without treatment, second month. Per hour.	Hours of packs in second mouth,
1.011	1.272	1.928

Thus the average confirmed the observation of individual days of treatment. The rise in the average elimination of urea in the second month, was associated with an increased consumption of food.

On the other hand, the average elimination of urea for an entire period of twenty-four hours which included a pack, sank below that of the days on which no pack was given (0.858 grms.). This observation is strikingly confirmed by another case. (See Table.) It shows that a movement of compensation takes place after the exaggerated diuresis caused by the pack, in virtue of which the elimination, perhaps also the formation, of urea, is diminished.

Although this case resembled Case 1 in the coexistence of membranous colitis with intense anæmia, and a diminution in the menstrual flow that almost amounted to amenorrhœa, it differed from it in two important particulars.

1st. The relaxation of the blood-vessels seemed to be out of proportion to the deglobulization of the blood; and thus

this patient, though much less pallid, prostrated and starved than the other, suffered much more from headache, roaring in ears, and multiple vaso-motor disturbances.

2d. Perhaps in connection with this fact, the membranous discharges from the colon were accompanied by an habitual tendency to diarrhœa, while in the first existed most intense constipation. From the irritability of the colon, the case was not very well suited to the cold packs. After seven or eight of these had been given during a period of two weeks, and the patient had been eliminating about two grammes of urea during the hour of pack, she began to wake up in the morning early, with a feeling of chilliness, which was shortly followed by a large loose passage from the bowels. This made her feel quite sick and faint.

Thus the pack seemed to confirm the existing morbid tendency to passive dilatation of the abdominal blood-vessels, and was on this account abandoned.* Could the patient have been induced to persevere systematically with the cold enemata (which invariably arrested the diarrhœa, membranous discharges and pain accompanying them), until the hyperæmia of the colon was removed, there is reason to think that much might have been accomplished by a subsequent hydro-therapic treatment.

As it was, at the end of six weeks, the patient was somewhat improved. The membranous diarrhœa had ceased, and with it the dragging pains in abdomen and hips. More particularly, a menstrual flow had occurred for the first time in four or five years, and the patient, instead of remaining confined to her bed or room, went about as usual at the menstrual period. The packs were then interrupted, the other treatment continued with further results, not important to record here.

* In very anæmic women, with vaso-motor neuroses dependent on anæmia rather than on hysteria, I have several times observed the often daily occurrence of one or two large passages, attended by a feeling of giddiness and great prostration. The phenomenon evidently repeats Goltz's experiment of paralyzing the splanchnic nerve.

The case is principally noted for the sake of comparing the eliminations of urea with those of other and more favorable cases.

Case 6.—Mrs. L. M., æt. 24. Is too complex to be related in detail. The profound anæmia of the patient was complicated by the effects of a marked anteflexion of the uterus, with chronic hyperæmia of the endometrium, for which local condition local treatment was instituted. The cold packs were given principally on account of the anorexia, which had existed for years, and which had kept the patient in a state of chronic inanition. After the cold packs and massage, she felt, for the first time, an appetite; was able to eat, and for a week or two at a time, would be relieved of the nausea which had become almost habitual with her. Table III, gives the analysis of urine as regards urea, for four packs. The patient reacted very well in these. As in Table I, it is seen that the amount of urine is very much increased; and the increase in the elimination of urea is in proportion to this. The great total increase of urea on February 26th, was associated with an increase in the amount of food taken, principally milk.

CASE VI—TABLE III.

Date.	Form of pack.	Amt. urine in c. c.	Per cent. urea.	Amt. urea.	Urea per hour.	Amt. urine per hour in c. c.
Feb. 19th	Pack and mass. 2 hours.	177.144	1.8	3.188	1.594	88.572
" 20th	Before pack.	590.48	2.6	15.352	0.877	33.74
" 20th	After pack.	295.24	1.8	5.314	2.961	117.00
Feb. 24th	After pack.	265.716	1.3	3.454	1.973	151.20
" 26th	24 hours without pack.	177.144	2.3	40.743	1.697	73.81
" 26th	After pack.	177.144	1.7	3.011	2.011	118.09

Case 7.—Miss N. O., a young lady æt. 21, suffering from chloro-anæmia of moderate severity, but complicated by severe trigeminal neuralgia, and also by spasmodic dysmenorrhœa. The latter condition was associated with some chronic hyperæmia of the endometrium, causing stricture of the internal os; otherwise no uterine disease. The patient had been treated for months by iron, and also by the most approved remedies for the neuralgia. In summer, when in the country, would seem to derive great benefit from the iron; in the winter "ran down" again completely. The stomach was very irritable, and frequent attacks of

gastric catarrh increased the headache and debility of which the patient complained.

The iron and phosphorus which the patient had been taking were continued, and on March 31st, the hydro-therapic treatment began. The urine was analyzed much more completely than in the other cases, as shown by Table IV. The packs were always enjoyed from the beginning; the patient reacted well, growing warm, though not perspiring. At the end of the first week, she already felt decidedly stronger. On April 12th, reported herself as having been remarkably free from neuralgia, notwithstanding the occurrence of some moral excitement, such as would usually bring it on. On April 26th, the tenderness on pressure, formerly constant over the supra-orbital nerves, had quite disappeared, though some tenderness remained over the supramaxillary. On May 27th, had had no neuralgia for three weeks, and announced herself as "feeling splendidly." In the interval, a sponge tent had been introduced into the uterus to dilate the os; and the following menstrual period had passed with scarcely any pain. On June 1st, the patient went out West for the summer.

The Table IV relating to this case, has been drawn up with a great deal of care, and we think an analysis of its data will pay perusal.

Calculating the averages per hour from this Table IV, we have: In hours outside of packs and massage, calculated in five days (March 31st, April 3d, 8th, 10th, 12th).

Urea.	Extractive.	Inorganic salts.
0.971.	0.432.	0.341.

For the five days adjoining, in hours of pack (March 31st, April 2d, 7th, 9th, 11th).

Urea.	Extractive.	Inorganic salts.
1.295.	0.347.	0.511.

Thus a decided increase in the urea, a slighter increase in the inorganic salts, a diminution in the extractive.

In the second month of treatment (see Table II), the averages per hour for the time outside of packs, were:

Urea.	Extractive.	Inorganic salts.
1.309.	0.803.	0.653.

For the hours of packs.

Urea.	Extractive.	Inorganic salts.
1.405.	0.685.	0.554.

CASE VII.—TABLE IV.

First Month		Amount urine in c. c.	Solids in grms.	Inorganic	Urea	Extractive	Per cent. urea	Per hour urea	Per hour Inorganic	Per hour Extractive	Per hour Amount
March 31st . .	Before pack : 21 hours	472.384	28.066	3.779	14.643	9.644	3	0.681	0.175	0.448	21.97
	After pack : 3 hrs.	73.81	4.299	0.885	2.435	0.979	0.974	0.974	0.354	0.393	29.52
April 3d . . .	Before pack	516.67	34.914	9.226	19.633	6.055	3.7	0.968	0.439	0.288	24.60
	After pack	180.00	5.87	1.08	3.60	1.191	2	1.20	0.36	0.397	60.00
April 7th . .	After pack	172.00	6.812	1.978	4.30	0.534	2.5	1.433	0.659	0.178	57.00
April 8th . .	Before next pack	531.432	34.67	6.111	20.194	8.365	3.6	0.96	0.291	0.398	25.306
April 9th . .	After pack	125.000	6.116	1.50	3.50	1.116	2.8	1.40	0.60	0.446	50.00
April 10th . .	Before next pack	509.289	30.852	5.85	19.352	5.65	3.8	1.018	0.307	0.297	26.805
April 11th . .	After pack	195.000	6.815	1.462	4.290	1.063	2.2	1.70	0.584	0.322	78.00
April 12th . .	Before next pack	22½ hrs. 767.624	50.079	11.130	27.634	11.315	3.6	1.288	0.494	1.731	34.11
April 16th . .	After pack	115.000	5.459	0.862	3.22	1.377	2.8	1.288	1.839	0.551	46.00
April 17th . .	Before next pack	546.194	33.088	6.554	19.662	6.872	3.6	1.062	0.354	0.372	29.52
April 18th . .	No pack 1 hr. massage 21 hours	797.148	49.219	9.167	27.800	12.252	3.5	1.309	0.436	0.598	37.959
April 19th . . Not warm for an hour	After pack 3 hours	118.000	7.010	1.239	3.894	1.877	3.3	1.298	0.413	0.625	39.35
April 21st . .	After warm pack 2 hours	118.000	Influ 5.733	enza 1.652	3.068	1.053	2.6	1.534	0.826	0.526	59.00
April 22d . .	Before next pack	546.194			22.847		Influence of cold 4.00	1.038			24.863
	After cold pack	140.000	7.013	1.82	3.920	1.273	2.8	1.568	0.748	0.489	56.00
April 23d . .	Before next pack	560.956	35.943	8.414	21.316	6.213	3.8	1.121	1.449	0.328	29.524
April 25th . .	After pack 1¾ hours	90.	4.927	1.080	2.70	1.147	3.	1.542	0.617	0.656	51.00
April 26th . . 1 day	Before next pack day bef. men.	472.384	31.368	6.377	17.005	7.986	3.6	0.944	0.354	0.444	26.243

Total for 24 hours	Urea	Inorganic	Organic	Totals for 3 days		
				Urea	Inorganic	Organic
March 31st	17.078	4.664	10.623	31st to 8th 64.805	31st to 8th 23.059	31st to 8th 26.768
April 3d	23.233	10.306	7.246			
April 7th—8th	24.494	8.089	8.899	9th to 17th 77.598	9th to 17th 27.358	9th to 17th 27.393
April 9th—10th	22.852	7.35	6.766			
April 11th—12th	31.924	12.592	12.378	18th to 23d 82.845	21st to 26th 37.097	21st to 26th 30.748
April 16th—17th	22.822	7.416	8.249			
April 18th—19th	31.694	10.406	14.129			
April 21st—22d	25.915					
April 23d	25.236	19.234	7.486			
April 26th, day bef. menst.	19.705	7.457	9.133			

There is still, therefore, an increase in the average of the urea, but it is less than in the first month, apparently because the general average elimination of urea is increased. The elimination of extractive and of inorganic material is absolutely increased for the hours of pack, and it is even more increased during the other hours, so that on this month the hours of pack show, in this respect, an inferiority.

As already noted, the calculation of averages in the solid constituents of the urine is misleading. The best estimate of the effect of the pack, is obtained by comparing the quantity and composition of the urine eliminated during and after them.

During the first month uniformly, and during the second with only two exceptions, the amount of urea during the packs was increased.

The elimination of organic matters other than urea (estimated by the method described in the foot-note to p. 2), generally rose and fell with the urea. On the 7th and 9th of April, however, the rule was reversed, and the elimination during the packs was much less than during the rest of the day.

As compared with the amount of urea the amount of other organic matter was not uniform in either direct or inverse proportion.

Generally speaking, however, the amount of organic matter rose and fell with that of the urea, standing to it in the proportion of from 1 : 2 to 1 : 3. In one case during the hours of the pack, when the amount of urea was unusually large (4.30 grms., April 7th), the amount of organic matter was unusually small—0.534 grms., or only $\frac{1}{8}$th. In another case—in the hours before the pack—when the amount of urea was unusually small, 14.643 grms. (March 31st), the amount of organic matter was unusually large, 9.644 grms., a proportion of 1 : 1.5.

The elimination per hour of inorganic salts was generally increased during the pack. On April 3d, however, the amount after the pack was slightly below the amount per hour in the period preceding it—although on this day the elimination of urea and of organic matter followed the usual rule. Also on the 8th when the patient received massage without the pack, the amount of inorganic material was a trifle higher than during the next pack.

The total amount of solid material eliminated in the urine in twenty-four hours, whether urea, extractive or inorganic matter, was apparently not changed by the treatment. The amount of urea remained constantly rather low (see Table IV). Estimated in periods of three days taken from the postmenstrual, intermenstrual and premenstrual week, the sum followed the law which we have elsewhere demonstrated for the menstrual cycle.* The amount was lowest in the postmenstrual week (64.805 grms.), rose in the intermenstrual week (77.658 grms.), and was highest in the premenstrual week (82.845 grms.). On the day before menstruation, as we have often observed in persons who suffer from dysmenorrhea, the amount suddenly fell to a lower point (19.715 grms.) than on any day in the month, except on the first day of the postmenstrual period; the extractive, however, rose.

There is, finally, one observation most important when taken in connection with the fact that during the two or three hours of the pack the absolute amount of solid materials in the urine was increased. This is a second fact: that the total amount of urine was increased during this same period—often almost doubled; while the per cent. of urea was, comparatively, decreased, often as much as 1 per cent. (see Table I). On this account we should infer that during the pack the increased elimination of urea was due to the

*Question of Rest for Women.

increased elimination of water which carried off by the kidneys a large proportion of excrementitious material.

The observations carried on during the second month on the same patient (see Table V), corresponded in all respects to the preceding. The packs were recommenced immediately after menstruation, but the analyses of urine were not made until the second week—the 13th of May. It is noticeable that in this month, when the patient was feeling remarkably well, the amount of urea and also of inorganic material during the premenstrual week was increased.

CASE VII.—TABLE V.

Date.	Second Month.	Amt. urine in c. c.	Solids in grms.	Inorg.	Urea.	Extractive.	Per cent. urea.	Per hour urea.	Per hour inorg.	Per hour extract.	Per hour amt.
May 13	After pack, 3 hours,	206.668	5.297	1.55	3.366	0.441	1.6	1.102	0.516	0.147	68.889
" 14	Before next pack, 19 hours.	782.386	36.459	3.911	20.342	12.206	2.6	1.070	0.205	0.643	41.179
" 16	After pack, 2½ hours,	132.858	7.738	1.129	2.391	4.218	1.8	1.195	0.564	1.61	66.429
" 17	Before next pack, 19 hours, ...	826.672	40.449	11.573	23.146	5.730	2.8	1.218	1.461	0.243	43.509
" 19	After pack, 2½ hours,	221.43	8.772	1.992	4.867	1.913	2.2	1.946	0.767	0.865	88.57
" 20*	Before next pack, 18 hours, ...	974.292	51.977	10.717	29.928	11.132	3.0	1.623	0.565	0.619	54.127
" 22	No pack nor massage, 15 hours, ...	442.860	30.955	5.313	19.728	5.714	4.5	1.328	0.354	1.709	29.524
" 23	After pack, 2¼ hours. Just precedes menst.	55.00	3.45	0.77	2.20	0.49	4.0	0.977	0.342	0.118	28.00

* Feeling splendidly.

Total for 24 hours.	Urea.	Inorganic.	Organic.	Totals for three days before menst.		
				Urea.	Inorg.	Organ.
13 to 14	23.648	5.461	12.647	88.760	31.494	29.197
16 to 17	25.537	12.702	9.948			
19 to 20	34.095	12.709	13.045			
22 to 23	21.928	6.083	6.204			

CASE VIII.—TABLE VI.

Date		Amount urine in c. c.	Amt. in grms.	Inorganic	Urea	Other organic	Per cent. urea	Per hour urea	Per hour inorganic	Per hour organic	Per hour amount
June 23d . .	Before first pack.	925	29.095	8.325	18.500	2.270	2	0.804	0.362	0.903	40.22
June 24th . .	After pack 2 hours.	120	2.656	0.600	2.041	0.016	1.7	1.02	0.30	0.008	60.00
June 25th . .	Before next pack.	935	31.588	11.687	18.70	1.201	2	0.85	0.551	0.904	42.50
June 26th . .	After pack 2 hours.	95	3.984	1.520	2.28	2.464	2.4	1.14	0.76	0.092	47.50
June 27th . .	Before next pack.	560.656	22.219		19.072		3.4	1.03			30.32
June 28th . .	After pack.	50			1.50		3	0.75			25.00
July 1st . .	Before pack	442.86	15.477		9.742		2.2	0.463			21.08
	After pack	50	2.679		1.55		3.1	0.620			20.00
July 5th . .	Before pack	501.908	17.541	3.513	9.536	4.492	1.9	0.433	0.159	0.204	22.859
July 6th . .	After pack	50	22.130	0.615	1.200	0.398	2.4	0.600	0.307	0.199	25.00
July 7th . .	Before next pack	472.384	29.134	5.668	11.437	12.029	2.4	0.519	0.257	1.067	21.472
July 8th . .	After pack	50	2.446	0.45	1.05	0.946	2.1	0.525	0.225	0.998	25.00
July 9th . .	Before next pack	575.718	16.097	5.181	11.514		2	0.548			27.415
July 10th . .	After pack	45	1.886	0.495	1.125	0.266	2.5	0.562	0.247	0.133	22.50
July 11th . .	Before next pack	708.576	38.44	8.512	17.125	1.61	2.4	0.778	0.386	0.851	32.208
July 11th . .	After pack.	50	2.33	0.70	1.15	0.48	1.4	0.575	0.35	0.24	25.00
July 14th . . Day before menst. .	Before pack	472.384	27.96	3.779	8.03	4.259	1.7	0.305	0.171	0.559	21.472
July 15th . . Menst. .	No pack Massage 1 hr.	45	1.153	0.405	0.72	0.028	1.6	0.720	0.405	0.028	45
July 17th . .	Bef. rubbing	339.526	15.03	3.395	9.846	1.789	2.9	0.447	1.154	0.081	15.433
July 18th . .	Rubbing 1 hr.	55			1.32		2.4	1.32			55
July 20th . . 1st day after menst. .	Before pack	869	12.896	2.952	7.759	2.195	2.1	0.352	0.132	0.099	16.61
July 21st . .	After pack 3 hours	162.382	4.161	1.461	2.598	0.102	1.6	0.866	.487	.034	54.127
July 22d . .	Before pack	649.528	24.967	7.794	16.238	.35	2.5	.738	.354	0.042	29.524
July 23d . .	After pack 3 hours	115	3.713	0.92	2.415	0.378	2.1	.805	0.316	0.126	38.33
July 25th . . Visit to sea-shore	Before pack 15 hours	200	44.27	1.80	5.600	1.454	2.8	.373	0.12	0.090	13.33
July 25th . .	After pack	130	2.877	0.664	2.08	0.133	1.6	0.693	0.221	0.044	43.33
July 28th . .	Before pack.	305	14.923	2.460	9.453	2.728	3.1	.429	0.111		—86 13.
July 29th . .	After pack	150	2.097	0.600	1.50		1	.500	.20		30.00

CASE 8.=Mrs. P. Q., a young married woman, æt. 22. First seen seven weeks after her first confinement. This was said to have lasted during three days. The perineum had been ruptured. On the third week, when patient first got up from bed, she was attacked with pain, chills and fever; was obliged to return to bed, and remained there for two weeks. Two weeks later, at the time of my examination, the patient was extremely weak and pale, unable to stand or walk, with almost absolute anorexia. The fundus of the uterus was within two fingers' breadth of the umbilicus. A slight thickening in the left cul-de-sac indicated a recent perimetritis.

The treatment was directed toward the general anæmia and toward the uterine subinvolution, principally the latter. Iron and nerve tonics were for the present postponed. The patient received f ℥ ss of ext. ergot. fld. every four hours; vaginal injections at first of salt water, afterward of tannin, and a daily cold pack, at first of one, then of two hours' duration, followed by an hour's massage.

Table VI gives the result of the examination of the urine under these conditions during a period of five weeks. This table is at once seen to differ in one particular from the tables of Case 7. The amount of urine eliminated during the hours of pack and massage is by no means always in excess of that eliminated during the same period of time in the rest of the day; and when there is an excess this is much more variable in amount. Thus on four occasions (June 28th, July 1st, 10th and 11th) the amount of urine per hour during the pack was less than the average by $\frac{1}{2}$, $\frac{1}{5}$, $\frac{1}{4}$ and $\frac{1}{3}$. On the other hand, the excess which was noticed in the majority of cases (10), varied from $\frac{1}{8}$ of the average to $3\frac{1}{2}$ times that amount per hour; and what is very noticeable, on two of the days on which the excess was most considerable, being twice (July 14th), or more than three times (July 17th), as much as the average, the patient received no pack, but only massage during an hour.

On all the days in which the amount of urine eliminated during the pack was increased, the amount of urea at the same period was increased also (10 observations). The increase varied from a scarcely perceptible amount ($\frac{1}{86}$ on June 8th, $\frac{1}{39}$ on June 10th) to $\frac{1}{9}$, $\frac{1}{8}$, $\frac{1}{7}$, $\frac{1}{5}$, $\frac{1}{3}$ the amount of the average, or even double and three times as much when the amount of the urine was increased in this proportion.

Calculating the averages per hour in periods of five days, as for

Case 7, we find, for five days without packs (June 23d, 25th, July 5th, 7th, 11th);

Urea.	Extractive.	Inorganic.
.676	0.785	.339

For adjoining days, hours of packs :

Urea.	Extractive.	Inorganic.
.772	0.307	.358

The diminution in the amount of extractive during the hours of the pack, as compared with the increase of urea, repeats an experience of Case 7. Comparing this fact again with another observation of Case 7, namely, the rise of extractive on the day before menstruation, coincidently with the fall of urea, we may draw the further inference that during the pack the increased elimination of urea is *not* alone due to the increased amount of urine, but that more organic material is converted into urea, leaving less for "other organic" or extractive. On the assumption that this conversion takes place in the liver, we may ascribe the increase to the increased circulation in this gland effected by means of the pack.

The rapid involution of the uterus, effected during the treatment, and also the large doses of ergot that this patient was taking, rendered the case somewhat peculiar. On July 26th, when the packs ceased, the uterus measured only 9 cm. It was to be presumed that during the treatment the fatty detritus from the diminishing uterus was circulating in the blood, perhaps acting as a diuretic. The ergot, on the other hand, tending to contract the abdominal vessels, should cause less water to pass through the kidneys; or, in other words, the usual effect of the pack of increasing diuresis would be counteracted. I do not know precisely what was the relation of time between the administration of the ergot and the pack, but it is probable that one dose came very near to the time of the pack. During menstruation the ergot was suspended, and it is noticeable that it is on two days of menstruation when massage was given, and on the first day after menstruation when the pack was resumed, that the amount of urine was so greatly in excess of the average *for this* individual.

On August 2d the patient was sent to the sea-shore. She had regained her appetite, had lost all pelvic pains, was able to walk

up and down stairs, slept well, and felt, although not yet strong, in pretty good condition. On September 12th the uterine cavity measured 8 cm. It subsequently became completely normal, and the patient, though of delicate appearance, entirely well.

I will now give briefly the record of three other cases, both of which would seem, at the outset, as suitable for hydro-therapic treatment as those described, but which nevertheless receive no, or only partial benefit from them.

CASE 9.—Miss R. S., æt. 27. Moderately anæmic, with continuous venous hum in jugular, but endowed with considerable muscular strength, and excellent digestion. A retroversion of the uterus existed, producing, however, no local symptoms beyond an occasional moderate dysmenorrhœa. The patient was extremely small of stature, with a head very well shaped, but large, out of proportion to the height. There were some traces of infantile rachitis. Whether as a result of this, or of the anæmia, or of the long standing retroversion, the young lady had suffered for years from nervous headaches, which, during the last two years, since a great moral strain, had assumed exceptional severity.

Cold packs and massage, iron and cod liver oil were recommended for the anæmia, while the efficacy of various direct palliatives was tried to relieve the headaches. The uterus was replaced with a pessary. The hydro-therapic treatment extended over 22 days, with an interval caused by menstruation of six days. The analyses of the urine are recorded in Table VII. Only urea, and occasionally phosphoric acid, was estimated. As in the other cases, the amount of urine during the packs was greatly increased, the percentage of urea lowered, but its absolute amount increased. That it was possible, in this patient, to greatly increase the amount of urine, yet even lower the elimination of urea, is shown by the observation of June 17th, fourth day of menstruation, when the amount of urine rose to 1040 C.C., yet the amount of urea was only 17.68 grms., or an hourly amount of 0.735 grms. Again, on the day of the first pack, June 8th, the amount of urine was nearly one-third the amount which had been passed in 20 hours, the amount of urea per hour was about 1½ times as much.

On the 10th the increase was more than double (2.44); also on the 12th. On the 13th the average amount rose, on the pre-

CASE IX.—TABLE VII.

Date.	Amt. Urine in c. c.	Amt. Urea in grms.	Per cent. urea.	Per hour urea.	Per hour P O 5.	Per hour urine.
June 7th.						
20 hours	600.00	15.	2.5	0.75	0.066	30.00
June 8th.						
$2\frac{3}{4}$ hours after pack . .	290.	3.19	1.1	1.16		105.00
June 9th.						
No pack	676.00	14.16	2.7	0.59	0.039	28.16
June 10th.						
3 hours pack	480.00	4.32	0.9	2.44		160.00
June 11th.						
Entire day, including pack of 10th	880.00	17.32				32.50
3 hours pack	860.00	3.00	1.	1.20		120.00
June 12th.						
20 hours before	600.00	13.20	2.2	0.66	0.48	30.00
3 hours pack	400.00	5.39	1.1	1.79		163.33
June 13th.						
21 hours	915.00	21.045	2.3	1.052		45.70
3 hours pack		3.555		1.185		
June 14th.						
Menstrual	560.00	14.56	2.6	0.728	0.0448	
June 17th.						
24 hours	1040.00	17.68	1.7	0.735		
June 18th.						
. . . . .	920.00	19.32	2.1	0.805	0.0732	
June 19th.						
. . . . .	885.00	20.355		1.017		
June 20th.						
20 hours	610.00	15.25		0.762		
3 hours pack		3.30		1.10		
June 21st.						
24 hours	580.00	18.56	3.2	1.773		
$2\frac{1}{2}$ hours pack	430.00	4.73	1.1	1.882		
June 26th.						
20 hours		16.00		0.80	0.07	
2 hours pack	540.00	3.96	0.9	1.98	0.18	
June 29th.						
20 hours		12.45		0.622		
3 hours pack, shower bath.	125.00	1.875	1.5	0.625		41.66

menstrual day, thus approximating the amounts of the two periods. After the two first packs following menstruation, the increase of urea was in much smaller proportion ; on the last day the amount was identical with that of the 20 hours preceding, while on an intermediate day (June 26th) the amount was, as before, doubled, as also the amount of phosphoric acid.

Clinically speaking, the patient reacted very well in the packs, and during the first week, *i.e.*, that preceding menstruation, had less headache ; felt better. But during the last week of the treatment, had constant headache, loss of appetite, and rapid pulse (96). At this time, as noticed, the proportionate increase of urea diminished. These circumstances all corresponded with those already noticed in Case 1, also a patient suffering from severe neurasthenic headaches.

Case 10.—Miss T. U., æt. 30, anæmic, but hysterical quite out of proportion to the anæmia. Principal complaint was of constant pain in the track of the right ilio-hypogastric nerves, without the least tenderness on pressure, either external or internal, in the ovarian region. The patient had no uterine or other local disease, but was profoundly preoccupied about herself, was indeed a typical case of hysterical egotism. Whether on this account or not it is difficult to say, as the hydro-therapic treatment was complicated with others that might probably better have been omitted ; but the patient, who, during the first month of treatment, improved, during the second became excessively fatigued after each pack, and at the close considered herself rather worse than better.

The urine analyses of this patient were, unfortunately, lost.

Case 11.—Miss V. W., æt. 20, pure chloro-anæmia, uncomplicated by dyspepsia or muscular atony, or uterine disturbance. Patient formerly suffered from severe headaches, which had ceased for a year or two before the time of consultation. The muscular development of the patient was remarkably fine ; her appetite was good, and digestion excellent. She was, however, extremely pale, and suffered from a constant sense of fatigue and somnolence. Her blood corpuscles, counted by Hayem's hematimetre, numbered 3,689,000, but it is probable that the hæmoglobin was diminished out of proportion to the aglobulie.

The patient was ordered tartrate of iron and potassa, 3 grms. every three hours, koumyss, rectal injections of blood, and the cold packs with massage. After a month of this treatment felt a great deal better, with much less fatigue and sleepiness. The pa-

tient went into the country, and passed an excellent summer. In October the debility began to return. Former treatment resumed, minus the rectal injections of blood, to which the patient had a great objection. But though persevered in for two months, no sensible improvement in the condition of the patient was observed. On the contrary, she had several severe attacks of headache.

From this crucial experiment we must infer that the apparent benefit derived from the hydro-therapic treatment on the first occasion, was really due to the blood injections. No analyses of the urine were made.

The general inferences to be drawn from these clinical experiments will be discussed in a later number of the ARCHIVES.

II.

In the clinical cases whose history has been related in the preceding number of the ARCHIVES, we studied the effect upon the urine of the cold pack followed by massage. We showed:

1. That the urine formed during this double procedure, and collected immediately afterward (the bladder having been emptied immediately before), was considerably increased in quantity, *i. e.*, the amount of water was greatly increased.

2. The amount of urea per hour was also absolutely increased, often doubled, but owing to the large excess of water, the percentage of urea in the urine was diminished.

3. The amount of extractive and of inorganic salts was generally increased, but in much smaller proportion than was the case with the urea. In not a few instances the amount of extractive was lessened.

4. In what seemed to be the typical cases of the action of the cold pack, the amount of water and of urea eliminated per hour during the rest of the day on which the pack was taken, fell below not only the amount eliminated during the pack, but below the average per hour of days preceding treatment, or days on which the pack was

not taken. Thus the total amount for the day was not changed by the treatment.

In some cases the urine was not examined comparatively for the hours of the treatment and for the rest of the day, and in these a total increase of urea for twenty-four hours was often observed. But if this persisted two or three days, symptoms of *malaise* or exhaustion occurred; sometimes the patient was chilly, sometimes suffered from severe headache, in all cases from a sense of great fatigue.

From the foregoing it would appear that whatever modifications of nutrition were effected during the pack and massage, were followed by a sort of movement of compensation in the opposite direction; and this movement of compensation seemed to be an essential part of the therapeutical effect produced.

5. On a few occasions, massage was given for an hour without being preceded by any pack. The urine eliminated during this hour showed an increase of water and of urea—less marked than was usually the case when the pack had also been given. In no case, however, did an opportunity occur to test the effect of the pack entirely separate from that of the massage. As it was important to ascertain this, if only to confirm or control the experiments that have been made by others in regard to the same question, the pack was given to three healthy women, with the observance of the same precautions as in the other cases. The results are recorded in Table VIII.

From this table, it is evident that the pack alone, apart from any form of muscular exercise, is capable of producing all the modifications of the urine already described; increase of water, of urea, and other solids. Moreover, as in the cases earlier described, during the hours following the pack, a movement of compensation occurs, in virtue of which, the elimination of both the fluids and the solids of

the urine falls as much below the average, as it had risen above it during the hours of the pack.

On two of the persons upon whom this experiment was made, no conscious effect was produced. The third, a

TABLE VIII.

	No. I.	Amount urine in c. c.	Solids in grms.	Inorganic	Urea	Other organic	Per cent. urea	Per hour urea	Per hour inorganic	Per hour organic	Per hour amount
M'ch 16th	24 hours . .	782.386			26.601		3.4	1.108			32.599
17th	24 hours . .	1062.864			28.696		2.7	1.195			44.286
18th	2 hours cold pack + ¼ hour	310.00			3.62	1.	1.2	1.608			137.77
18th	22 hrs. before and after pack	472.384			14.643		3.1	0.665			21.472

	No. II.	Amt. urine in oz.									Oz.
April 23d	24 hours . .	28.	48.153	10.746	29.760	7.647		1.24	0.447	0.318	1.16
24th	24 hours . .	26.50	43.751	10.562	26.601	6.588		1.108	0.440	0.274	1.10
25th	Before pack 4 hours . .	6.	9.905	2.834	5.491	1.580		1.372	0.708	0.395	1.50
	2 hrs. blanket pack . . .	3.50	6.019	1.601	3.203	1.215		1.601	0.800	0.607	1.75
	18 hours after pack . . .	37.50	40.449	10.746	22.320	7.383		1.240	0.597	0.410	2.08

	No. III.										
April 24th	24 hours . .	44.	48.428	14.289	28.579	5.560		1.19	0.595	0.231	1.83
25th	Before pack 8 hours . .	14.	21.721	4.143	10.772	6.806		1.346	0.517	0.850	1.75
	2 hours cold pack . . .	14.	10.619	1.243	5.386	3.99		2.693	0.621	1.995	7.
	14 hours after pack . . .	28.50	26.505	6.731	15.145	4.629		1.081	0.480	0.330	2.

rather anæmic woman, felt extremely fatigued, "used up." during the remainder of the day. The question now arises: Can these modifications of the urine, so unquestionably shown to have been effected by the treatment, be accepted

as an index to and measure of its beneficial effect on the patients? Can they, further, in any way furnish the explanation of such benefit?

The benefits derived may be summed up as follows:

1. Increase of appetite was one of the first results observed, and this, sometimes, when no other benefit was derived. In the two "neurasthenic" cases, where nervous headache was a prominent symptom, the appetite diminished rather than improved. In these same cases, as already seen (see preceding paper), very little improvement in health was obtained from three and from six weeks' treatment.

2. During a variable number of hours following the pack, the patient generally experienced a feeling of fatigue of various degrees of intensity, and by no means proportioned to the degree of debility existing previous to treatment. When this fatigue lasted all day, the pack was only given every other day; and, on the intermediate days, the patient, in the successful cases, felt decidedly invigorated.

3. In several cases where sleeplessness had been a distressing symptom, it rapidly disappeared after beginning the treatment.

4. As already stated, circumstances prevented us from measuring the blood of the patients by means of the hæmatimeter. But that a decided enrichment of the blood must have been effected, is shown by the reëstablishment of menstruation in three cases of prolonged amenorrhœa, with coincident amelioration and final disappearance of intense dyspeptic symptoms.*

5. In one case, a rapid involution of a subinvoluted uterus was initiated during the hydrotherapic treatment. But as ergot was freely administered at the same time, it is

* Among these we do not include the constipation, so remarkably obstinate in two of the cases; because this condition was especially treated by the large cold enemata, with the addition, in one case, of belladonna; in the other, of ipecac.

impossible to ascribe the satisfactory result entirely to the packs. But comparison, however, with numerous cases of uterine subinvolution treated exclusively by ergot, would lead us to believe that the rapidity with which the favorable result was brought about in this one, and certainly the rapid improvement in the nutrition, strength, and conscious feelings of well-being in the patient, were largely to be attributed to the packs and massage.

The question again presents itself: By what mechanism can we presume this treatment to have been influential in determining these various effects, all belonging to the one more general result, namely, improved nutrition of the blood and tissues?

The effects of the cold pack have been, by various observers, more or less accurately estimated on the pulse, the respiration, the temperature, the cutaneous nerves and certain functions regulated by them; finally, in general terms on the nutritive metamorphosis or "*stoffwechsel*."

Concentrating our attention upon one portion only of the phenomena attending the administration of the cold pack, we have made no precise personal researches in regard to the rest, and must supplement our observations by the experimental results which have been obtained by others. We must consider separately the initial effect of the pack, *i. e.*, the sudden application of cold, and the secondary effect—when the sheet has become warm.

1.—*The Pulse.* Winternitz, repeating, with graphic apparatus, upon human beings, the experiments made by Rohrig upon rabbits, arrived at a similar result: namely, that immediately after the application of cold to the skin the heart's action is temporarily accelerated; but in from three to ten minutes, the application continuing, the pulse becomes retarded. This, of course, is meant for such non-febrile conditions which we are alone considering. The temporary acceleration is ascribed to stimulation of the

accelerator nerves springing from the cervical cord: the more permanent slackening of the pulse,* to stimulation of the vagus,—when the impression shall have been transmitted as far as the medulla.

According to Kolmann (*British Med. Journal*, 1873), the pulse of a healthy man, which by a walk had been accelerated to 104, sank to 84 very shortly after entering the pack, and in an hour was at 60. Several times was observed a fall from 72 to 44. (Quoted by Winternitz.) A fall of the pulse in the pack was uniformly observed by us whenever looked for; fall proportioned with previous rapidity.

2.—*Respiration.* The first contact with the cold sheet, as every other sudden application of cold, provokes one or more deep, gasping inspirations, followed by a brief period of rapid respiration. After this the respiration becomes slower, but not in proportion to the pulse. "There are always fewer cardiac contractions to each respiration; and the blood, therefore, remains longer in contact with the air in the lungs, with a possibility of becoming more highly oxidized."—Winternitz.

3.—*Cutaneous nerves.* The shock of the cold sheet produces the same stimulating impression on the cutaneous nerves as is caused by the sudden application of cold to the skin in any other form. The stimulating impression is necessarily transmitted to various nerve centres, upon which it acts, and from which it is reflected along motor and vasomotor tracts according to well-known laws. In this part of its action, the cold sheet entirely resembles the cold shower bath or douche, but is less powerful, because the stimulating impression of cold is unaccompanied by the stimulus derived from the mechanical impact of the water.

4.—*Cutaneous blood-vessels.* These invariably contract under the first impression of cold. The contraction seems

* Die Hydrotherapie, 1877.

effected by means of local stimulation of the vaso-motor nerves, and of the muscular fibre of the blood-vessels, without the intervention of the vaso-motor centres. For, when there is normal reaction, the blood-vessels rapidly dilate,—more rapidly than would be the case as the result of vaso-motor paresis. The dilatation coincides with the first consciousness of nervous stimulus from the impression of cold; coincides, therefore, with the excitation of the cerebro-spinal nerves of the skin; is proportioned, both in rapidity and extent, to the susceptibility to stimulus possessed by the cerebro-spinal system, and may be considered, therefore, as an active dilatation effected under the influence of the cerebro-spinal nerves. In these respects, again, the initial effect of the cold sheet resembles the total effect of the shower bath or douche.

The effect on the pulse and respiration, however, is not identical with that of the shower bath, because it covers not only a period of acceleration of both, but a period of retard as well, whereas, throughout the entire time that a douche may with propriety be administered, the pulse and respiration remain accelerated. For a therapeutic influence on nutrition, it is the secondary retard which is of value, and this is perhaps the main reason why even the initial effect of the cold pack is more valuable in anæmia and states of denutrition than is the shower bath.* While in some cases of torpid anæmia the pulse may be slow, it is well known that in the majority of cases it is rapid and feeble; at all events, extremely variable at different times. In chloro-anæmia the typical pulse has been described as ample, the blood-vessels being well filled, though with watery blood, while the tension is extremely low, so that the percussion stroke of the sphygmographic trace is ab-

* In many neurotic conditions, unaccompanied by marked anæmia, the douche, on the contrary, is much more valuable than the pack, and in our short series of cases, we have seen that the latter seemed to fail precisely in proportion to the predominance of the neurotic element.

normally high. This hydræmic pulse is certainly by no means always present, even in typical cases of chloro-anæmia, and its character would be more likely to be changed, if at all, by other effects of the cold pack, to be considered later. The retard of the pulse determined near the outset of the application of the wet sheet, is chiefly of value—and of great value—when a quick, feeble pulse indicates that the blood passes at once too rapidly and in too small quantity through the tissues to properly nourish them. "The irritable weakness," or nervous irritation, so characteristic of anæmic patients, is largely dependent upon this condition, especially as it exists in the nervous centres and in nervo-muscular tissues. All the facts known in this connection, indicate that an imperfect supply of nutrient fluid to those tissues tends to prolong their functional activity in proportion as it interferes with their nutrition. Thus, insomnia; thus, anæmic cramp of many muscles. The imperfection in the supply may depend on the quality of the blood, or on the quantity delivered to the tissue in a given time. It is this latter imperfection which alone concerns us for the moment, for it is evident that the quantity of blood in the circulation remaining the same, the duration of its contact with the elements of tissues will be less when the rapidity of the circulation is greater.

Setting aside then the condition of the quality of the blood, and the functional irritation that has been proved to depend on its deterioration, it is not difficult to show that, even without such deterioration, rapidity of circulation favors functional activity and diminishes nutrition. The famous experiments on the circulation of glands, the contrast between the state of the circulation of the brain during sleep and wakefulness, the intellectual excitement coinciding with the acceleration of the pulse under alcohol, belladonna and hyoscyamus, and the intellectual torpor, accompanied often by evidences of improved nutrition,

when, under the same drugs, the pulse is slackened, either secondarily or primarily,—these and many other familiar facts suffice to establish the proposition.

Ranke has formulated the law: only fatigued tissues can be thoroughly nourished. Because in them alone (nervo-muscular tissues at least) the habitual alkaline reaction is exchanged for acidity, as acid "fatigue-products" accumulate during the activity of the tissue.

This acid reaction increases greatly the facility with which nutritive material can diffuse from the alkaline blood* into the elements of the tissue. In proportion as the nutritive material diffuses into the nerve or muscle cell, the acid fatigue products must diffuse out. An inadequate blood stream, which would bring an imperfect supply of nutriment, would also imperfectly remove this acid detritus. Ranke's very precise experiments have shown that, while a higher degree of acidity completely depresses the functional activity of a nerve or muscle, a slight degree of acidity excites this. When the fatigue-products are imperfectly washed away, just such a slight, exciting degree of acidity may be supposed to be maintained. By unduly prolonging the tonic contraction of the cell protoplasm, this permanent excitement opposes the penetration of nutrient material (see note *infra*). While, on the other hand, this *exciting* degree of acidity is far less favorable to the nutrient endosmosis than the acid saturation resulting from complete exertion, and accompanying complete fatigue and repose of the nerve or muscle cell. Thus re-

* *Die Lebensbedingungen der Nerven*, Leipzig, 1868. "The process of nutritive assimilation and disassimilation is always active, depending ultimately on the vital properties of the tissues. In all cells (necessarily) possessed of vital contractility, one may consider, exists a certain slight contraction, or tonus, of the cell contents. Since these are inseparable from the cell membrane, therefore must this elastic membrane sustain a certain traction. Let us assume that there are pores piercing this membrane perpendicularly, then, on account of the internal traction must these be funnel-shaped and closed at the lower extremity. If now the vital energy of the cell be paralyzed, the traction is lessened, the pores are opened, and fluids pass into the cell. The pores will remain open until closed by increased internal pressure from constantly growing mass of cell contents." Ranke, loc. cit., p. 87.

sults incomplete functional activity in the cell, owing to an inadequate reserve supply of material from which to elaborate force; incomplete formation of acids; incomplete removal of acids; hence imperfect nutrient osmosis from alkaline blood, and prolonged excitation of the functional activity of cell. The first step in this series precedes the conditions of the circulation we are considering; often, indeed, constitutes the congenital defect, upon which depend so many obstinate anæmias. But the other conditions may all be produced or removed temporarily by changes in the pulse, and consequent changes in the volume of the blood stream bathing the cell.

During the initial or shock period of the cold pack, the contraction of the peripheric blood-vessels raises the tension of the vascular system, so that blood streams through the muscles, nerve centres, and viscera, not only more slowly, but under a higher pressure; second condition favoring osmosis.

The rapid, shallow breathing of anæmic persons, like the rapid pulse, is said to be "an effort of nature" to compensate imperfection of oxidation due to the deglobulization of the blood by means of more frequent inspirations of air; and is directly due to irritation of the inspiratory centre by a blood poor in oxygen. The accelerated respiration following the deep inspiratory effort determined by the shock of cold, differs from the acceleration of anæmia, in that the inspirations remain more profound, and during the few minutes that this period lasts, more oxygen is taken into the lungs, and, whatever amount of hæmoglobine is in the blood, is enabled to become more nearly saturated. The subsequent slowing of the respiration may be in part due to this increased oxygenation of the blood, which, though lasting such a brief time, may suffice to lessen the irritability of the inspiratory centre; it is in part caused by the recumbent position. According to Rosenthal,* retard in

* Die Athembewegungen, 1862.

the inspiratory movements implies an increase in the resistance habitually generated in the respiratory centre together with the inspiratory force, and intermittently overcoming the latter. When there is more resistance, a large amount of force has to be generated in the inspiratory centre to overcome it; hence delay in the occurrence of an inspiration; which, however, is only more forcible when it comes. The respiration, during the first period of the pack, is deeper because slower, other circumstances remaining the same, and the increased facility for oxygenation, once initiated, is continued.

Stimulus of the cutaneous nerves may, in regard to its effect upon the nutrition, be variously estimated. Winternitz asserts that it directly increases the nutritive metamorphosis (stoffwechsel).

It is established (Liebermeister,* Jürgensen, Riegel†) that thermic excitation of the sensitive cutaneous nerves determines an increased production of heat in the muscles;‡ the abstraction of heat by the contact of cold being only effected in proportion to the secondary dilatation of the peripheric blood-vessels, permitting exposure to cold of a larger amount of blood (Riegel, Winternitz). There is no proof, however, that chemical changes in other tissues, or other than those involved in this production of heat, are determined by the initial shock of the cold sheet. Nor, as already noticed, do these take place in persons too debilitated to respond to the cutaneous excitation. These are chilled and remain chilly for a double reason. The direct effect of the cold is felt, not only on the skin, from which blood should be driven to the muscles, but on the superficial layer of muscles as well, which are similarly anæmiated instead of becoming flushed with blood. And, at the

* Theorie der Fieber.

† *Deutshes Archiv. f. klin. med.*

‡ Lersch, Pratktische Balneologie. Zuntz & Rohrig, *Pflüger's Archiv.*, 1876 (quoted by Foster). Samuel, Allgemeine Pathologie.

same time, the sensitive nerves fail to convey to the central nervous organs such impressions as are required to stimulate the production of heat. Such persons are frequently unable to bear the shower bath, failing to grow warm, and only becoming excessively fatigued and "nervous," by the frictions employed to establish reaction. We have seen several such cases.

The increased production of heat, determined by stimulation of the heat-regulating apparatus, irrespective of the amount of heat abstracted by the cold,* involves increased functional activity: 1st. In the sensitive afferent nerves. 2d. In one or more parts of the nerve centres. 3d. In centrifugal nerve fibres of some kind terminating in muscles. 4th. In the muscles, where are performed the chemical processes involved in the production of the excess of heat.† Thus the organism is induced to perform a definite, and no inconsiderable amount of work. On this account its nervo-muscular tissues,—or a large portion of them,—are brought into a condition favorable to nutritive assimilation.

The contraction of the cutaneous blood-vessels finally, and their subsequent dilatation even before the initial effect of the sheet has passed away, are both of importance in several ways. During the period of contraction, heat accumulates in the body from diminished radiation; the muscles are irrigated with an extra supply of blood, facilitating the extra production of heat necessitated in them; the tension of the vascular system is raised, and, as already seen, as soon as the pulse slackens, the blood, circulating more slowly, and under increased pressure through the

* The provision for rapidly diminishing any excess of heat which may be thus produced, renders unnecessary a precise adjustment of the production of heat to its loss; and there is no proof that any such precise adjustment exists. The oscillations of gain and loss continue until the equilibrium of the normal standard is regained.

† The *normal* temperature of the body is probably the result of the algebraic sum of chemical processes taking place in all tissues; some of which produce, others absorb heat.

nerve centres, muscles and viscera, offers more favorable conditions for nutritive absorption. Nor is this all. Writers who have estimated the effect of the cold pack or cold bath merely in its relations to the temperature of the body, have dwelt principally on the retreat of blood from the skin to the muscles during the contraction of the cutaneous blood-vessels. There can be no doubt, however, that the retreat of blood from the surface goes much farther—reaches the viscera, especially the abdominal viscera, which are liable to become engorged under the influence of a chill. For the purpose we are considering, it is this effect that is especially important. If the hyperæmia of any of the abdominal viscera already exist, this new engorgement with blood may become a great inconvenience, as was shown in one of our cases, where the patient suffered from chronic membranous colitis. It may even be a source of danger, when the pack is given too near to a physiologic period of abdominal plethora, as digestion or menstruation; or even more so when there exists a lurking peritonitis. In a case submitted to treatment since the publication of our first article, and where, from some misunderstanding between the patient and the assistant, the pack was unduly prolonged in spite of absence of reaction, a slight pelvic peritonitis was the immediate consequence.

But when the reaction is normal, the column of blood which sets inward toward the chylopoietic organs very soon turns outward again, accelerating the entire circulation of these organs in the same direction. That is to say, the stagnation of blood, so frequent in anæmic persons in the mucous membrane and submucous tissue of the stomach and intestines, often keeping up a chronic catarrh, and constantly interfering with primary absorption from the alimentary canal, tends to become quickened into normal circulation by the return current of blood toward the sur-

face of the body, as the cutaneous vessels dilate. As a most important result, more nutriment is carried into the general circulation, and, with the abatement of the gastro-intestinal hyperæmia, the appetite revives.

The effects of the cold pack just enumerated, and belonging to the first five, ten, or fifteen minutes of its application, are, as we have several times noticed, common to it and some other applications of cold, as the douche or plunge-bath. Beneficial as they are, their advantages are much limited by the necessary brevity of their duration. The stimulation of the nervous system may indeed persist for some time after the cessation of the bath; indeed, in healthy persons habitually does so; does so in patients hysterical or "neurasthenic" out of proportion to their anæmia. For all such persons, therefore, the plunge-bath, shower-bath, or spinal douche is preferable to the pack. But in several of our successful cases, and in some others not published, the patient had long been in the habit of taking a daily plunge or shower-bath, without ever experiencing from it the peculiar benefit derived from the packs. It remains, therefore, for us to consider what physiological effects are produced by the prolonged application of the packs in addition to those characteristic of their beginning period; further, what conditions of the anæmic state are likely to be favorably impressed by such influences?

The slackened respiration, slackened pulse, and dilatation of th ecutaneous blood-vessels, already begun during the in itial period, continue throughout the pack,—at least, unless this is prolonged sufficiently to induce sweating. In this case the pulse becomes accelerated again. Sweating was never induced in the cases we have recorded; indeed, we have never seen it with a pack of two hours' duration, except in one case not included among those analyzed. With a dilatation of superficial blood-vessels insufficient to perceptibly redden the skin, but sufficient to give a feeling of

warmth and render the skin easily susceptible to redden by friction, the originally high arterial tension is exchanged for a lowered tension; cooling of the body from the dilated blood-vessels of the skin is prevented by the blankets which closely envelope the patient; even normal radiation is thus prevented, body heat is retained, the moisture of the wet sheet is warmed, and the patient passes gradually from a cold to a warm vapor-bath. In this the blood-vessels and the muscular fibres of the skin become more and more relaxed; the relaxation extends to all the muscles; a direct sedative influence is exerted upon the peripheric nerves. In addition to these obvious effects, Wintermitz justly calls attention to the condition of the nerve centres, affected partly by transmission from the periphery of the sedative impression, partly by diminution in their vascular supply. According to Schüller,* direct observations of the exposed brain of an animal wrapped in a moist pack, showed a narrowing of the pia blood-vessels, a sinking of the brain, and diminished excursion of its pulsations. The animal slept. In other experiments, Mosso has shown that during sleep the peripheric parts of the body increased in volume,† an effect which could only be produced by an increased afflux of blood to them, necessitating such a diminution of blood in central organs as was shown by direct observation to exist coincidently with sleep.

Sleepiness during the pack nearly always occurs in successful cases, and we have found the greatest amount of benefit to accrue when the patient was able to sleep for half an hour after completion of the pack and the massage.

If, during the first period of the pack, we may assume, for reasons already stated, that blood circulates in increased volume and under increased pressure through the nerve

* Quoted by Wintermitz.

† If I recollect aright, the same fact has been demonstrated by François Franck, in his essay on the changes of volume of organs. Travaux du Laboratoire de M. Marey, vol. ii, 1876, p. 1.

centres, and that in consequence, the acid fatigue-products which had been maintaining a permanent excitement of nerve elements, could be completely removed, the immediately subsequent diminution of blood supply, effected during the second part of the pack, cannot fail to be a great advantage. For it lowers the functional activity of the nerve tissues, that has been unduly prolonged, and brings them, therefore, into the condition which is a necessary preliminary to the beginning of nutritive assimilation. The diminution in the blood supply is not sufficient to interfere with this latter process, for it is not below the point which exists in sleep, the physiological period for nutritive assimilation in nervo-muscular tissues. Accepting Ranke's law for these tissues, "that they are only nourished when fatigued," *i. e.*, relaxed, we may see further, in the muscular relaxation induced by the warm moisture of the pack, a condition most favorable for the nutrition of the muscles.

According to the experiments of Rohrig and Guntz,* the establishment of an equilibrium between the temperature of the skin and the surrounding medium, is sufficient to diminish the peripheric nervous irritations upon which the maintenance of muscular tonus depends.

The direct cause of the tonus is the chemical process excited by the stimulus transmitted from the nerve centres, and which is identical in quality, only differing in quantity, from that which takes place during muscular contraction. It is this which is arrested by equilibrium of temperature—which is arrested, therefore, during the second stage of the pack, immediately after the exaggeration effected during the first stage. Unusually complete repose is therefore provided, after unusual excitation of one form of functional activity—that, namely, which is involved or implied in the increased production of heat.†

* Quoted by Nasse—Chemie u. Stoffwechsel d. Muskeln, 1879.

† It is admitted that the chemical processes, of whatever nature they may

We say one form of functional activity, by a certain license of expression,—referring in part to the chemical processes which antedate both muscular contraction and the production of heat in the muscle,—and which, as we have seen there is so much reason to believe, are identical in the two cases. The fact of cardinal importance, and so well demonstrated, that during muscular contraction the elimination of carbonic acid from the muscle is increased, while the absorption of oxygen remains the same (Ranke, Hermann), shows that carbo-hydrates are oxidized at the expense of oxygen already contained in the muscle. This oxygen is certainly not free, but is an element of some complex molecule, probably albuminous, whose decomposition is effected, like that of other albuminoids, by means of a ferment, which becomes active under appropriate nervous stimulation of the muscle. Guided by this celebrated hypothesis* (which does scarcely more than combine and formulate undoubted facts), we may affirm that when heat has been produced by the impression of cold upon the skin, the above series of changes is initiated in the muscles, beginning with the decomposition of the (probably) albuminous molecule contained in the muscular

really be, which take place in the muscle during its contraction, do not differ qualitatively from those which are constantly going on in the muscle at rest. The latter are the source of a large part at least of the constant heat of the body, as the former serve to develop a temporary excess of heat, coincidently with contractile force. Since the sensible heat developed in the muscle is in inverse proportion to the external work accomplished by this contractile force (see p. 70 of text), it should follow that any agency other than muscular contraction, which is capable of stimulating the production of heat, should be effective in proportion to the coincident immobility of the muscles. Hence, the immobility necessitated by the pack should permit a maximum development of heat, in response to the thermic irritation of the cutaneous nerves by the application of cold. The massage which follows, and which is sometimes supposed to be the principal agent in warming the patient, must be much less effective for that purpose. For whatever heat may be generated by it is rapidly eliminated through the dilated blood-vessels of the skin ; and whatever muscular contraction is excited by the massage serves to consume the heat, or else to diminish its production by absorbing the force liberated by the chemical processes which are the necessary antecedents both to heat and to work.

* Hermann, Untersuch. über den Stoffwechsel in Muskel. Voit and Pettenkofer, *Zeitsch. für Biol.*, 1866. Parkes, Proceedings Royal Society, vols. xv and xvi.

juices, and ending with the formation of carbonic acid, of lactic acid, perhaps of other acids also. We do not know whether the experiment has been tried of testing the reaction of muscles during an increased production of heat, to see if it resembled that existing during contraction; but it is certainly an experiment to perform. If this (theoretically probable) acidity exist, the muscle would be brought, by the necessity of reacting to the cold sheet, into the condition most favorable for nutritive absorption from the alkaline blood, as it is during ordinary physiological fatigue. —(Ranke.)

From this it becomes evident why warmth generated by the resources of the organism, cannot be replaced by the warmth of a vapor-bath, into which the patient should be plunged at the outset. The fact, that by means of the cold pack the organism is compelled to perform work, while, simultaneously, provisions are being made both for repose and for nutritive assimilation, is certainly one of the most important peculiarities of this method of hydro-therapeutics.

The vigorous massage which, in our clinical cases, followed the cold pack, served to combine several of the effects produced at different periods of the packing. Thus, it stimulated the cutaneous nerves and dilated the superficial blood vessels to a greater extent than before, so that the skin reddened intensely as it rarely did from the pack alone. Again, the passive movements of the limbs which caused actual contraction of almost all the muscles of the body, increased the vigor of muscular circulation, and tended to obtain, in proportion to the permanence of this effect, its known results in increased production of heat, in muscular nutrition, in the disappearance of chronic muscular fatigue, in relief to abdominal plethora.

Judging merely by appearances, an observer would prob-

ably be ready to ascribe much greater influence in these respects to massage than to the cold pack. Weir Mitchell's popular little essay on "Fat and Blood," has recently familiarized the public with a view of the nutritive benefits to be derived from pure massage, which, in our opinion and according to our experience, are rather exaggerated. Dr. Mitchell speaks of a muscle as "a species of throbbing heart," whose contractility can be excited mechanically merely by friction and pinching from the surface of the body. That some effect upon the circulation may be thus produced cannot be denied; the frequent success of massage in removing fatigue, aching, pain and lameness from fixed positions, or even from sprains, testifies to this possibility. Passive movements of the limbs at each joint, which, in our cases, were always combined with the friction movements, come, however, much nearer to the standard effect as obtained by voluntary contractions, than can be the case with either frictions, or slapping, or pinching of the muscle, as far as it may be reached. These manœuvres may and do cause dilatation of the blood-vessels in the muscles; they may, when sufficiently profound, cause isolated contraction of fibres, limited to the point of contact, but they can excite no general contraction of the active muscle.

In passive movements, however, where the two points of insertion are mechanically approximated to each other, and the entire muscle shortened, to be alternately extended or stretched, the characteristic effects of muscular contraction may be obtained, though to a less degree than after vigorous voluntary muscular exercise.

It is an interesting question whether the less degree of fatigue experienced by patients after massage and passive movements, as compared with that caused by voluntary motion, be due simply to the fact that in the first case the

muscular contraction is less energetic, in other words, that the quantity of exertion is less; or whether there be some qualitative difference, in virtue of which the passive motion is rendered at once more endurable to anæmic persons, and more advantageous for nutrition. We incline to the latter opinion, because simple diminution in the quantity of voluntary muscular contraction, far below the degree really induced by massage, is far from sufficing to avoid fatigue. Indeed, in the class of persons we are considering, the degree of muscular exertion involved in the act of walking, or even sitting upright, is well known to cause an intolerable and persistent uneasiness, while more active exercise is liable to excite such severe palpitations, headache and other symptoms of exhaustion that it cannot be sustained at all.

A portion of the difference between the effect of voluntary and of passive exercise, depends on the diminished work, which, with the same amount of contraction, is performed by the muscles in the latter case. As has been shown by Béclard,* and confirmed by Fick,† much more warmth remains in the muscles which contract without raising a weight external to the body, than in those which do perform this work. In the latter case, either a portion of the heat produced is converted into work, or else the production of work by the force liberated during muscular contraction, subtracts just so much from the amount of heat which can be produced by the same force. But in ordinary muscular exercise, the muscle is at least compelled to move the weight of the limb, while in passive exercise this weight is sustained by the hand of the operator. The amount of work performed is therefore reduced to a minimum; and, could the muscle be made to contract power-

* Traité de Physiologie, 1868, which re-states the experiments of the original essay.

† Quoted by Hermann. Allg. muskel-physik, in new "Handbuch der Physiologie." As shown by Hermann, Béclard's experiments are not really refuted by those of Heidenhain, still less by the counter statements of Dupuy, in *Gaz. Méd.*, 1865.

fully, the amount of heat generated and saved would be at a maximum. The contraction is less powerful than *might* be effected voluntarily; but probably more powerful than would be effected by the debilitated individual submitted to the massage. Moreover, as shown by Heidenhain's experiments, stretching of the muscle, independent of the force of contraction, accelerates the chemical changes which result in the production of heat; and stretching can be very well performed passively. But the most important cause of the toleration, without excessive fatigue, of passive exercise, lies in the preparation for muscular contraction by means of increased blood supply, effected by the preliminary frictions which should have determined a dilatation of the blood-vessels.

It is often customary to speak as if the increased blood supply in massage were the direct and constant consequence of the muscular contraction, as it is in health, and within certain limits of muscular exertion. But when a *fatigued* muscle is forced to contract, the blood supply ceases to increase; the production of heat diminishes;* indication that the chemical changes which should be effected are diminished. Whether from clogging of the muscle with acids (Ranke, Nasse), or from commencing coagulation of the myosin (Hermann), or from consumption of the (albuminous?) molecules whose fermentative "splitting" was the source of contractile power, or from a combination of these conditions, the muscle which has once fallen into a state of fatigue cannot be made to improve its circulation or its nutrition by being stimulated to fresh contractions. It will, until utterly exhausted, respond to such stimulus, but only to fall into greater exhaustion.

These considerations have been entirely overlooked by Mitchell, in the popular essay already referred to, perhaps

* Carrieu, De la Fatigue, *Thèse de l'agrégation*, 1878.

because in that essay no scientific accuracy was aimed at, but only certain rough, practical results. In this particular case, however, the theoretical inaccuracy constantly tends to defeat the practical benefit. Anæmiated muscles are in a state of chronic fatigue. For reasons already suggested, it is true that massage *may* succeed in exercising such muscles without increasing fatigue, on the contrary, while improving their nutrition by direct effect on the circulation, and not indirect, as a consequence of their contraction.

But when this is the case, we belleve it is owing, as already stated, to the dilatation of blood-vessels previously effected. When, as not unfrequently happens, the movements of massage do not secure this increased vascularization, independent of muscular contractions, the latter are often more exhausting than beneficial. It is precisely in such cases that comes into play with such advantage the peculiar mechanism by which the cold pack is enabled to flush the muscles with blood.

III.

In the August number of the ARCHIVES, we began to analyze the therapeutic results obtained by us in the cold pack, in the light of some of the most recent researches on the physiology of nutrition. We directed particular attention to the fact that, in anæmia, the same condition of the muscles which renders voluntary exercise difficult or impossible, exists to interfere with the benefits that might be expected from massage.

Since in health, and after adequate repose, voluntary muscular contraction determines an increased flow of blood to the contracting muscles, it is often expected that passive contraction of anæmiated muscles will do the same thing, and thus obtain at once, increased nutrition of the muscles, and derivation of blood from the internal organs. But we have seen that experiments upon *fatigued* muscles show,

that the contractions which may be excited in them are not effected in precisely the same way as in health. The blood-supply does *not* increase indefinitely in proportion to muscular exertion; indeed, if it did, muscular fatigue would be impossible, and the muscle could go on contracting forever. But after a certain limit of exertion has been reached, although increased stimulus will continue to cause contractions at the expense of the material stored up in the muscle, new material ceases to arrive or be assimilated, and the acid fatigue-products accumulate because insufficiently washed away. There is thus double proof that the blood stream is lessened, and that the muscular contractions then performed do not suffice to increase it.

Anæmic muscles resemble fatigued muscles in that their blood-supply is insufficient, and their contraction is therefore attended by pain. They differ, in that in anæmia this state has not necessarily been determined by excessive muscular exertion. But from this difference we must not, therefore, infer that the insufficiency of blood-supply is the primary element of the morbid state: rather that this has been determined, in many cases at least, by the inaptitude of the muscle to appropriate to itself material from the blood out of which to construct its contractile material in sufficient abundance. This inaptitude, often congenital, may certainly be closely compared with that which is induced when, by prolonged contraction, the store of contractile material in the muscle is nearly exhausted, and, when contraction, during the persistence of the muscle, is unable to renew the supply. *Why* it should be so unable, I believe, is not at present clearly understood, but the fact, remarkable as it is, is demonstrated both by exact experiment and by common experience.

Under these circumstances, if we wish to enlarge the blood-supply and increase the nutrition of the muscles, we must reverse the initial procedure, and, keeping the mus-

cle at rest, endeavor to attract blood to it by methods acting directly on the blood-vessels.

We have seen that friction, as employed in methods of massage, is one means of dilating the blood-vessels. It is a method synergistic with that initial effect of the cold pack already described ;* whereby, after stimulation of the sensitive nerves of the skin, the influence of the vaso-motor constricting nerves is overcome, and the blood-vessels dilate.† When the cutaneous blood-vessels are dilated, we may expect that those in the superficial layer of muscles will be dilated also. Further, since stimulation of nerves terminating in muscles has been shown by Ludwig to cause dilatation of the blood-vessels of these muscles (see note below); and since the cutaneous nerves, doubly stimulated by cold and by friction, constitute the superficial part of the plexus which sends nerves to the muscles lying deeper, we perceive additional reasons for expecting an afflux of blood to these muscles during the pack and massage. Of the two stimulants we should expect the cold to be more effective in determining this afflux, than the friction, because of the special susceptibility of the heat-producing muscles to thermic irritations. The rapid production of heat observed to follow the application of cold to the sur-

* ARCHIVES, August, 1880, p. 56.

† The statement made on page 57 of our second article, that "this active dilatation of cutaneous blood-vessels, is effected under the influence of the cerebro-spinal nerves," expresses the sequence of many easily observed facts, without entering into the still disputed question of the existence of special vaso-motor dilating nerves. In regard to these, Hermann remarks : "The existence of direct vaso-dilator nerves, as maintained by Bernard and Schiff, is still undemonstrated."

We would subscribe to the further remark of this distinguished physiologist : "Their modes of action in any case were incomprehensible."—*Physiol.* p. 74. Berlin, 1874.

The demonstration of vaso-dilating properties in the chorda tympani, the sciatic, and some other nerves, certainly affords no proof that the dilatation is effected by special fibres, rather than by inhibition of the vaso-constrictor nerves. Researches made since the publication of Hermann's treatise, have indicated with probability the existence of local vaso-motor mechanisms, acting differently upon the blood-vessels to which they belonged, according to the different nerve fibres which liberated their activity. Ludwig has shown that stimulation of muscular (spinal) nerves always causes a *dilatation* of the blood-vessels of the muscle.

face of the body, can only be effected in virtue of a dilatation of muscular blood-vessels, which, as the result shows, is brought about immediately after the abstraction of heat.

In the cold pack, the production of heat continues until the wet sheet has been warmed through. The warming is facilitated by the blankets which, preventing the escape of heat, utilize all that is produced. During all this time the afflux of blood to the muscles continues, and is only checked when, in the establishment of an equilibrium of temperature, the thermic irritation disappears (see p. 66 of our second article). Thus is secured the necessary preparation for muscular exertion which is so important to obtain where anæmiated muscles are compelled to contract. By it these muscles are brought into a condition of vascularization approximating that of health ; their contraction, therefore, may be followed, as in health, by a still further afflux of blood and by increased chemical metamorphosis,* leading ultimately to a larger accumulation of contractile material.

We may now profitably return to the main purpose of this paper, and inquire what relations, if any, exist between the phenomena that have just been described, and the modifications of the urine we have ascertained by experiment to take place.

An increase of urea, after the pack, has been observed by hydropathists in isolated cases, as quoted from Wemott by Lersch † among other writers on the subject. Winternitz mentions an increased secretion of urine as the result both of the cold pack and of friction in the cold wet sheet. He attributes this entirely to the increased arterial pressure in

* We do not say, as is sometimes said, "increased *nutritive* metamorphosis ;" for it seems conclusively proved that for the muscle, as for the nervous tissue, the period of nutrition does not coincide with the period of functional activity, but alternates with it. Thus, as has been so remarkably demonstrated by the respiration researches of Pettenkofer and Voit, more carbonic acid is eliminated during the day and during exertion ; but more oxygen is absorbed at night and during repose.

† Loc. cit., p. 247.

the abdominal vessels, caused by the contraction of the cutaneous blood-vessels, and relates cases to show that under certain circumstances the rise of tension may be sufficient to cause albuminuria (?). At all events, albuminuria was observed as a consequence of the treatment.

Ludwig's famous experiments upon the effect of increased or diminished pressure in the renal artery sufficiently demonstrate the possibility of increasing at least the excretion of water from the kidneys by means of an increase in the pressure of the abdominal blood-vessels. Neither can there be any doubt that this abdominal pressure is increased during the first period of the pack, when the blood is driven from the surface of the body. It cannot do otherwise than accumulate in the vast vascular area of the abdominal blood-vessels, and the mechanism by which this is accomplished is pretty well known. When the blood-vessels of the periphery contract, pressure on the central parts of the vascular system increases. Foremost among these central parts is the centre of all, constituted by the cavities of the heart: increased pressure here stimulates the depressor nerve; this stimulus conveyed to the medulla inhibits the vaso-motor centre, and especially the vaso-motor nerves which run to the abdominal blood-vessels in the splanchnics. Hence the dilatation of the abdominal blood-vessels which takes place, and in proportion to the contraction of the cutaneous.

But if the above series of events were the only cause of the diuresis observed after the pack, its influence should terminate as soon as the cutaneous blood-vessels begin to dilate. As much urine should be secreted after a pack of fifteen minutes' duration as after one of two hours. This, however, was by no means the case. With some persons, indeed, a sense of fulness in the bladder made itself felt early in the pack; but this was rarely very noticeable under half an hour. In an hour it generally became very marked, and

if the pack lasted two hours was liable to be almost unendurable. In some cases not included in our list, and in which the urine was not analyzed, the patient was always compelled to empty the bladder immediately upon being taken from the pack, and before submitting to the massage.

It would seem, therefore, that the increased elimination of urine, begun during the first period of the pack, continued throughout it, either under the continued influence of the original cause, or of some other condition, coincident or supperadded.

Now, during the grand oscillatory movement of the circulation we have now so often described, all the tissues of the body are necessarily subjected to a more abundant osmotic "streaming." It is characteristic of anæmic tissues that they habitually retain a much higher degree of water than is normal (Ranke). In many cases of the so-called "fat anæmia," the tissues—especially the nervo-muscular tissues—are probably "waterlogged," or have become nearly as hydræmic as the blood. It is extremely probable, though difficult to demonstrate experimentally on the human subject, that a considerable portion of the water eliminated by the kidneys during the pack, is derived, not from the blood alone, but from the tissues. If at any given time exosmosis from the tissues has been arrested by an abnormal equilibrium of density between them and the blood, removal of a certain amount of water from the blood should, as in the eliminative treatment of anasarca, by raising the density of the blood, facilitate diffusion into it of liquid from the more watery tissues. Such diffusion, continuing during the second period of the pack, would continue to increase the amount of water passing to the Malpighian tufts of the kidneys.*

* In nervous tissues the percentage of water is normally greater than that of the blood, but the habitual excess is somewhat increased during exhaustion (Ranke, Tetanus). It is this increase which would be removed by a diuretic agency.

But, in the third place, the question presents itself whether water be not formed in the organism during the pack, as Flint suggests that it is formed during excessive muscular exertion. That more water may be eliminated from the body than has been ingested, is unquestionable. Thus, in one of Voit's hunger researches, where the dog received only 33 grms. of water and 358.1 grms. of oxygen in the day, he eliminated with the urine 105.6 grms., and with respiration 400.5 grms., or a total of 506.1 grms. of water.*

In this experiment, the disproportion between the amount of water ingested and that eliminated is much greater than is generally seen in ordinary conditions of nutrition. Indeed, as Funke remarks,† the disproportion is more apt to be the other way; only one-third the amount of water which has been ingested is eliminated, the rest is stored up in the body, increasing its weight. But in the conditions of the experiment the body was wasting; with especial rapidity was fat disappearing. As far as we now know, the complete disappearance of fat from the body implies its ultimate conversion into carbonic acid and water, with increased elimination of the latter both by lungs and kidneys.

Now, during the increased production of heat artificially determined by the cold pack, as during the increased production of fever (Liebermeister), there is an increased elimination of carbonic acid,‡ to be attributed to increased oxidation of non-nitrogenous, *i. e.*, carbo-hydrate substances contained in the muscles. The oxidation of carbo-hydrates is not as necessarily attended with the formation of water

* Pettenkofer and Voit. *Zeitschrift für Biol.*, Bd. v.

† *Lehrbuch der Physiologie*, Bd. i. Voit claims to be the first to call attention to the great variation in the amount of water contained in the body of the same individual at different times. But it is Ranke who has estimated this minutely for isolated muscles and nerves.

‡ The large amount of water eliminated in some of the wasting diseases of children, especially during the incipiency of tuberculosis in the brain or elsewhere, may *possibly have a* similar origin.

as is the oxidation of fat; but it may occur,* and, in view of the increased elimination of water demonstrated to coincide with the increased elimination of urea, we may infer that it does.

The elimination of an excess of water from anæmic tissues, cannot fail to be an immense advantage. "Fat anæmias," proverbially difficult of cure, may benefit greatly by the elimination of water effected in another way, namely, by the Turkish bath. But this bath has, for many patients, many inconveniences, and can by no means take the place of the pack.

The increased circulation of water through the abdomen, and hence through the chylopoietic viscera, is of great importance in improving the nutrition of anæmics. We have already dwelt upon the manner in which the pack may act beneficially upon the chronic gastric or intestinal catarrhs so frequent in anæmic persons. But there are many cases in which such catarrh does not exist; cases in which, however, nutritive absorption seems to be slackened, and, perhaps, the elaboration of the digestive products in the chylopoietic viscera imperfectly performed. In these cases, although no other symptom of primary indigestion exists, there is very generally constipation. We may infer that the torpor of the muscular coat of the intestine extends to the muscular fibres of the villi, whose central duct thus fails to receive the peristaltic compressions which favor the first onward movement of the chyle. Of all the causes which should retard the elaboration of digestive products in the liver and other glands, many are imperfectly known to us; but a languid circulation may certainly be counted as one. Increased force of circulation of the liver, as effected by the pack, produces the same results as the ingestion of large quantities of water; the entire portal circula-

* Winternitz. Loc. cit., Bd. ii, p. 391.

tion, both vascular and lymphatic, is stimulated; more material is taken up from the alimentary canal, the metamorphoses of this are facilitated, and, as an ultimate result, the production of urea increased. This increased production of urea is often still accepted as proof of increased nutritive assimilation in the tissues; although, in itself, an increased elimination of urea can only indicate an increase of waste or disassimilation. But at present we are not authorized, without special proofs, to derive the urea from the organized tissues at all.

The famous researches of Bidder and Schmidt, those of Bischoff and Voit, and especially the numerous and more recent researches of the latter, prosecuted alone or in association with Pettenkofer, have brought into view an entirely new set of conceptions in regard to the nutritive metamorphosis of albumen. According to these views, the urea eliminated in ordinary normal conditions is not derived from albumen that has become organized into tissues, but comes from the albumen of the food yet retained in the circulation. The destructive metamorphosis of this albumen, that never is used for plastic purposes, constitutes what Schmidt first called the "Luxus-consumption." To it should be largely due the elaboration of force employed in the various mechanisms of the body.

The proof of this doctrine is found in the following facts of observation and experiment:

It has long been a matter of observation that the amount of urea is more precisely and markedly affected by the nature of the food ingested than by any other influence; an increase of the albumen of the food is immediately followed by a corresponding increase in the urea of the urine; and a diminution of albuminous food will, with similar promptness, cause a diminution of urea.

On the other hand, as has been more recently demonstrated, it is certain that the increased functional activity of

richly albuminous organs—the muscles—does not increase the amount of urea in the urine. It would be superfluous in this place to even allude to the well-known experiments by means of which this demonstration has been effected.* But it is, perhaps, not superfluous to indicate the line of proof for Voit's now celebrated doctrine of "circulating," "organized," and "store" albumen, inasmuch as this doctrine is not yet universally admitted, and the questions involved in it are important in the pathology of anæmia.

Voit† estimated the urea excreted in 24 hours by a healthy dog, then deprived the animal of all food during a number of days. On the first day of starvation of a dog previously well nourished, there was no marked difference in the amount of urea; but on the second day was noticed an abrupt fall in the amount of urea eliminated, and this amount continued to diminish for several days. A period of equilibrium was then reached, in which the daily elimination of urea or of nitrogen remained sensibly the same. Since no food was taken, and since time enough had elapsed to consume all remains of food stored up in the organism (the period of this consumption being indicated by the progressive variations in the eliminations of urea), the urea now eliminated could have no other source than the albuminous tissues of the organism. From the nitrogen of this urea, which constituted 3.4 per cent. of the fresh albuminous tissues, the amount of these that had been decomposed in the process of wasting, could easily be calculated. This amount, however, did not account for the entire loss of weight, as observed from day to day. By means of Pettenkofer's respiration apparatus, the loss of carbon, hydrogen and oxygen, in excess of what could

*See especially Fick and Wislicenus; also Parkes already quoted.

† Ueber den Kochsalz; also many essays in *Zeitschrift für Biolog.*, from Bd 1 onward. See also analogous researches of Adamkiewicz, Das Pepton, and criticism (favorable to the theory) of Funke, *Lehrbuch der Physiologie;* Landois and Hermann, in their respective text-books, accept Voit's doctrine without reserve.

have been contained in the albuminous tissues and eliminated from the body as carbonic acid and water, could also be ascertained, and the sum total of losses thus estimated was found to correspond to the total loss of weight sustained by the animal during the period observed.

The amount of nitrogen eliminated during the "stationary" period, or while, with complete inanition, this amount remained constant from day to day, was accepted as measuring the proportion of organized albumen capable of oxidation and of conversion into urea. In later periods of inanition,—when the animal lived so long,—the amount of urea increased, and, coincidently, starvation fever set in; double indication of an abnormal destruction of albuminous tissue. During the earlier period, on the contrary, the larger amount of urea must have been derived from food previously taken. For it varied in proportion to the albuminous richness of this food; and the variations were much greater than could be explained either by the supposition that urea had previously been retained in the body, or by presumed variations in the condition of the albuminous tissues.

By subtracting from the urea of the first hunger day that of the stationary hunger days, was obtained the proportion of urea which is derived from the stored-up albumen.

Thus, in one of Voit's dogs, the urea on the first hunger day was 37.5 grms. On the fifth day, when the elimination had become stationary, it was 12.6 grms. This, subtracted from 37.5 grms., leaves a residue of 24.9 grms., which must have been derived from the albumen of the food previously ingested. This 24.9 grms. is 66 per cent. of the whole amount of the first day. From a series of similar experiments, Voit arrived at an average of 70 per cent. as belonging to the stored albumen, and used for consumption when the organism was deprived of food.

When, to a starving dog arrived at the stationary period, food was given in increasing quantities, an ascending series of urea eliminations was constructed, wherein the excess of urea corresponded to the amount of nitrogen contained in the food ingested. Nor did only the excess so correspond; for, with increasing quantities of nitrogenous food, a condition was reached in which all the nitrogen of both urine and fæces was covered by the nitrogen ingested; and there was no surplus to be accounted for by decomposition of organized tissues. This is the condition of Nitrogenous Equilibrium,—when the food entirely protects the tissues from oxidation, and when the body, though eliminating immense quantities of urea, may actually gain in weight.

From these data we cannot see how it is possible to avoid the conclusion that, in all circumstances but those of starvation, the greater proportion of the urea of the urine comes from the food ingested on the same day of the observation, or during the two or three days previous. Voit admits, from the result of other experiments and calculations, that in ordinary circumstances, about one per cent. of the daily urea is derived from the organized albumen of the tissues, *i.e.*, from their wear and tear.

To this theory Foster* objects that it involves the assumption that oxidations of albuminous substances habitually take place in the blood circulating in the vessels; and he considers this assumption inadmissible on account of many facts which indicate that oxidations never take place in the blood, but only in the tissues.

It is difficult to see how such an objection can be urged by any one who has seriously studied Voit's elaborate papers on the matter. For his expression, "circulating albumen," by no means implies albumen still contained in the blood-vessels, *but albumen circulating through the elements of the tissues and not organized into their structure.* "It is

* Text-book of Physiology, p. 362.

always the nutritive fluid changing and circulating through the organs, which is decomposed, and not the organised part of the muscles. * * Since the muscles constitute the greatest bulk of the organs, in them must the most albumen be decomposed, and the greatest mass of the nitrogen of the excreta must come from them."—*Zeitschrift für Biol.*, Bd. i, p. 238.

In researches on cholera uræmia, Voit found a large amount of urea in the muscles (where, normally, as is known, exists only a trace). He observed the same thing in nephrotomized dogs.

The great generalization made by Voit in regard to the purpose of nitrogenous metabolism, precludes the idea that he imagined this to occur in the blood-vessels. He * compares the stream of albumen passing through the elements of the tissues, to the stream of water passing over the wheel of a mill. As the mill wheel turns in virtue of force derived from the water, so the functions of living tissues † are performed in virtue of force derived from the constant decomposition of albuminous molecules, and [is implied] as the mill must be immersed in the water, so the tissue-elements must be in immediate contact with the albuminous molecules, whose more or less explosive decomposition is constantly liberating force.

Foster himself offers a suggestion which is by no means incompatible with the theory of Pettenkofer and Voit. It is known that leucin is formed in the intestine during the pancreatic digestion of albumen, as it is in artificial oxidations of the same substance; known also that leucin is convertible into urea, and that unless large quantities have been ingested, experimentally, into the alimentary canal, no leucin, but an excess of urea, appears in the urine. From these facts it may be, perhaps, inferred that the

* Pettenkofer and Voit. Untersuch. über den Stoffverbrauch.—*Zeits. für Biol.*, Bd. ii, p. 368.

† As, for instance, the muscular tissues.

"Luxus-consumption" of large quantities of proteic material is effected in the intestine by conversion of albumen into leucin, the latter, being absorbed, passing off in the urine as urea.

Taken simply in this way, however, the "Luxus-consumption" would have no physiological significance further than as a provision for getting rid of proteid material ingested in excess of the real needs of the body; a mere provision against gluttony. It is inconsistent with many facts, and especially with those indicating that the decomposition in the organism of albuminous substances, as well as of carbohydrates, is necessary for the development of the vital forces. "Indeed," observes Foster himself, "the whole secret of life may almost be said to be wrapped up in the occult properties of certain nitrogen compounds."*

The real theory of the "Luxus-consumption" implies that these metabolic functions constitute the principal uses of albuminous food, and explains, therefore, why an amount of such food, largely in excess of what is needed for the repair of tissue, may be not at all in excess of the total needs of the economy. It implies, moreover, that these needs are met, during the series of changes that takes place in albumnoids, after absorption from the intestine.

Leucin, however, is far from being the only product of pancreatic digestion. So far as we know at present, it is only a minor, an accessory product. Peptone is formed in the intestine as well as in the stomach, and Adamkiewicz's experiments show that peptone may be organized into the tissues, and also may be eliminated in the form of urea. It is thus certain that leucin is not the only antecedent of urea; it is even probable that the latter may be derived from several different substances, each of which represents a preliminary term of albuminoid oxidations.

It is the leucin origin of urea which has furnished a

* Loc. cit., p. 371.

weighty argument in proof of the formation of urea in the liver.† For in acute fatty atrophy and some other diseases of the liver, urea diminishes or disappears from the urine, and in its place appears a proportionate amount of leucin. This is exactly what might be expected if the conversion of leucin into urea habitually depended on the normal activity of the hepatic cells.

It does not, however, follow, whatever may be the proportion of albumen which is converted into leucin, that all the leucin which passes from the intestine to the liver should there at once become converted into urea. It is very possible that the hepatic cells at first merely so modify the leucin as to render it capable of further changes while circulating in the tissues. The existence of urea in the liver suggests that perhaps the last step of the process, like the first, may be accomplished by the hepatic cells.

Schützenberger has shown that albumen is broken up with hydration into various products under the influence of hydrate of baryta. His pupil, Quinquaud, has obtained these same products from many albuminous tissues, similarly treated by hydrate of baryta, under high pressure and temperature maintained for several days. Of all tissues so treated, the parenchyma of the liver gave the most abundant yield of leucin, tyrosin, and urea. "We conclude that the cellular act of denutrition sustained in the parenchyma, is analogous to the splitting produced in the laboratory under the influence of hydrate of baryta, heat, and pressure. * * * The hydration is effected by means of a proteic ferment, which replaces the hydrate of baryta." Quinquaud, Chimie Pathologique, pp. 304–311.

Foster's suggestion is useful in pointing out a supplementary intermediate origin for urea, when unusually large

† See Murchison. Lettsomian Lectures on Functional Diseases of the Liver; also Quinquaud, Chimie Pathologique, Paris, 1880, p. 314. An essay on the formation of urea in the liver, is to be read before the British Medical Association on its meeting of this year.

quantities of proteid material have been subjected to the action of the pancreatic juice. But it does not disprove the conversion of peptones into urea. Nor does it nullify the rôle of "circulating albumen," when this term is understood to include all the intermediate products existing between the protein ingested and the urea eliminated. Between urea, on the one side, and the peptones and leucin * formed in the alimentary canal, on the other, exists a wide gap, occupied by a series of chemical compounds, which must be formed within the tissues, either of some one organ, or, more or less, of all. All these changes, up to the formation of urea, imply the splitting of albuminous molecules into simpler compounds; a process constantly attended by liberation of force.

We have entered upon this rather long discussion, whose problems, after all, we could do no more than indicate, because the complete explanation of the increase of urea observed during the cold pack, is inseparable from the theory of the origin of urea. For us, the very first question to decide is, whether the excess of urea appearing in the urine during the hours of the pack, depended on an increased formation of urea during this same period, or merely on an increased elimination from the recesses of tissues in which it was accumulating.

No less an authority than Ludwig has asserted the increased "washing out" from the tissues, of previously formed urea, as an explanation of the large amount which appeared in the urine on the first days of Voit's hunger experiments. Voit, however, has shown that in such cases no urea could be found in either the blood or the organs; and further, that when urea was ingested, it could all be recovered from the urine within 24 hours.

On the supposition that, during the pack, urea previously retained in excess was washed out from the tissues, we

* And tyrosin.

should expect to find, during the hours preceding the pack, some indication of such retention. But there is no such indication, and no experimental proof, indeed, that when the highly soluble urea has once been formed in the tissues, it fails to be immediately eliminated from the body, so long as the kidneys are healthy.

Variations in the elimination of urea depend, therefore, on variations in its formation. But these may affect any of the steps in the long process by which albuminous substances reach their final stage of oxidation, beginning with the absorption of peptones (and of leucin) from the alimentary canal. Sluggish absorption of albuminoids must diminish the amount of urea in the urine, as decidedly as would the diminished ingestion of proteid material. We have pointed out* several conditions, frequently met with in anæmic people, which render primary absorption sluggish; and have showed how the pack, by increasing the force of the abdominal circulation, may quicken this primary absorption.

But, further, if there be a similar sluggish intervascular circulation in the glands, especially the liver, through which the albuminoids must pass during their progressive metamorphoses, these metamorphoses may be retarded. Though we must doubt the retention of urea in the tissues, there is no reason to doubt the frequent retention of intermediate, less soluble products, when, from any reason, they are not passed rapidly enough from cell to cell, or through the capillaries of the organs in which they are being elaborated. Now, agents which increase osmosis and intervascular streaming, might be supposed to favor these chemical changes, just in proportion as such changes are dependent upon the elementary circulation of the imperfect products.†

* Page 21.

† And there is every reason to suppose that the dependence is very close. Many, if not most clinical phenomena, necessitate prolonged movements upon

Conspicuous among this class of agents are water and chloride of sodium, both of which increase osmosis, and also must accelerate the decomposition of circulating albuminoids, for they both considerably increase the production of urea.

The increased circulation in the abdomen determined by the cold pack, and which we have already shown to be the cause of the diuresis, should produce much the same effect on the formation of urea, as does the ingestion of large quantities of water. In the liver, there will be increased vascular pressure and transudation; and, in consequence of the *vis a tergo* thus applied, an increased circulation from cell to cell. Thus, on the one hand, a greater quantity of albuminoid material brought to the liver, by quickening of primary absorption; on the other hand, such increased interstitial circulation in the liver, as should facilitate the metamorphosis of the newly arrived albuminoids.* As one final result of both, increased production of urea.

If, as has so often been supposed, the urea came from the disintegrating plasma of tissues, its increase, in states of denutrition, must always be considered a misfortune. But coming, as we see no reason to doubt that it does, from the albumen of the food, the urea eliminated may serve in several ways to indicate nutritive assimilation.

In the first place, as we have seen, it may show that, under the same circumstances of diet, more food has been absorbed from the ailmentary canal; part of which *may* have been retained and stored up without decomposition.

In the second place, whenever an albuminoid molecule is split up in the formation of urea, and its nitrogenous portion eliminated, there is a possibility that the organism will

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one another of the substances which are to be changed by mutual interaction. We see no reason to assume,—as seems to be often tacitly done,—that all the substances which transude through capillary walls remain at once permanently outside them. Rather must we admit a constant in-and-out streaming throughout all the elements of the tissues,—capillaries, cells, conjunctive tissue spaces,—until the product of any tissue has been sufficiently elaborated to be finally removed from it.

* Peptone and leucin.

retain and assimilate the non-nitrogenous portion. Whether, in any given case, this has been done or not, can only be known with certainty after analysis of the products of respiration. But the assimilation may be inferred whenever an increased elimination of urea is found to coincide with improved nutrition and increase of weight.

In the third place, the formation of urea, indicating as it does the decomposition of albuminoids, is in itself a proof, and to some extent a measure, of an evolution of force; and an increased production implies an increased evolution of force. To provide, immediately or remotely, for this evolution of force; to thus prevent destruction of organized albumen for the same purpose, is the principal function of the proteids of nutrition. When, with ingestion of the same amount of albumen, more urea appears in the urine, it is proof that a larger proportion of albumen has been completely burned, and that proportionately, more force has been placed at the disposal of the mechanisms of the economy. To revert to Voit's simile, the stream of albuminous molecules, in which revolve the wheels of the organism, has been deepened, so that the myriad revolutions could be more easily accomplished.

Now, in the anæmias we are considering, the organism is principally suffering from deficiency of force,—from functional debility. The increased development of force effected in its tissues, as testified to by the increased elimination of urea, should ultimately constitute a tonic as positive as alcohol or quinine, but one whose more complex influence is not so immediately perceptible.* But we have seen that whenever the increased elimination of urea continued during the hours following the pack, so that the total amount for 24 hours was increased, the patients were fatigued rather than invigorated. If the excess of urea continued for several days, decided symptoms of malaise appeared. When the

* For *immediately* after the pack patients are much fatigued.

pack was entirely beneficial, the increased production of urea during the pack was compensated by diminished production afterward, so that the daily amount was rather below than above the average for that patient. Thus, the rhythm of the urea excretion offered a fairly correct indication of the benefit that might be expected from the packs.

When the permanent excess of urea was attended with symptoms of exhaustion, the patients, in spite of improved appetite, had not yet succeeded in increasing the daily amount of food, in proportion to the increase of osmosis and of facilities of waste. It is possible, therefore, that the organized albumen of the body was still insufficiently protected by the ingesta, and, under the influence of an increased elementary circulation, was decomposed in excess of what could be easily tolerated.

The diminished production of urea after the pack, may be explained in several ways.

1st. To the extent to which production had been increased by the temporary increase in the abdominal circulation, must it diminish when the habitual equilibrium of the circulation was restored.

2d. Similarly, to the extent to which the excess of urea was derived from increased chemical processes in the muscles, sustained during the production of heat, must it diminish when, by equilibrium of temperature, these processes were temporarily arrested.

3d. The increased elementary circulation, followed at first by increased decomposition of the circulating albumen, may subsequently, though not coincidently, determine an increased movement of assimilation. This movement may include, on the one hand, albuminous materials absorbed in more abundance from the alimentary canal, and now retained without decomposition; on the other hand, the non-nitrogenous portion of the albumen, which

has been decomposed, and whose nitrogenous part has been eliminated as the excess of urea. That the movement of elimination and of assimilation did so alternate, was indicated, not only by the rhythm of the urea excretion, but by the fact that our patients were nearly always tired immediately after the pack, sometimes extremely so, but felt invigorated a few hours later, that is, during the period of diminished production of urea.

We know, as an important result of the respiration researches, that the oxygen consumed by the organism is not absorbed at the moment that it is required for use, but previously; and conversely, that the oxidations constantly going on, are not effected at the expense of the oxygen which is simultaneously being absorbed, but at the expense of that which has previously been stored up.* Consequently, an increased production of urea consumes a larger amount of stored-up oxygen. This increased consumption determined by the pack, like that caused by exercise, is followed (not accompanied) by an increased absorption of oxygen. During this period, oxidations, and consequently the production of urea, must be diminished.

Further: Pettenkofer and Voit have shown that the absorption of oxygen increases with the amount of *organized* albumen existing in the economy. To the extent, therefore, to which the increased amount of circulating albumen (obtained by quickened primary absorption) could be converted into organized albumen, should the absorption of oxygen be increased.†

But if this be so, we discern new reasons for a peculiarly beneficial effect of the cold pack in anæmia. The best-

* See note, p. 166. To use a rather homely simile, "raw" oxygen is of no use to the tissues; it must be mellowed, *i.e.*, rendered active by long keeping. In other words, as has been suggested, it must first enter into combinations, from which it must be subsequently liberated in a nascent state, *i. e.*, as ozone.

† See table of gradual increase of hæmoglobine under the influence of richly albuminous diet, in essay, by Leichtenstern, Untersuch ueber den Hæmoglobin-Gehalt des Blutes, p. 43, Leipzig, 1878.

defined characteristic of anæmia hitherto recognized, is the deficiency of hæmoglobine in the blood, whether this be caused by a numerical deficiency of red corpuscles, or by a deficient constitution of corpuscles numerically sufficient.* The significance of this poverty in hæmoglobine depends on the diminished absorption of oxygen which it implies. It is customary to add, "and which it necessitates," looking at the deficient absorption of oxygen as being exclusively due to the lack of hæmoglobine in the blood to take it up. In the light of Pettenkofer's researches, however, we may inquire whether a deficient absorption of oxygen be not itself a cause of the gradual disappearance of the hæmoglobine.

It has been seen that all organized albuminoids *fix* oxygen in a way presenting many analogies with the fixation of oxygen by hæmoglobine, itself an organized albuminoid. Also that the hæmoglobine does not take up the same amount of oxygen whenever exposed in the lungs to the same amount of air, but takes up more at night than in the daytime, and takes up more for individuals whose tissues are rich in organized albumen than for others. If the poverty of these tissues reaches a certain point, or if, perhaps, their condensing activity be diminished in some, as yet, unknown way, we may suspect that the hæmoglobine would then take up less oxygen for carriage,† and, finally, in accordance with a general law, atrophy with the failure of its functional activity.

Unquestionably, in anæmia, the hæmoglobine is atrophied: there is much less than the normal proportion in the blood. Possibly even that which is present is not normally saturated with oxygen. This deficiency is at the basis of the general functional debility, which, far more

* As shown by the recent researches of Hayem and of Gowers.

† 1.76 ccm. for every gramme is the normal amount. Foster, Text-book, p. 274.

than waste of tissue, is the conspicuous morbid symptom of anæmia.

If, therefore, during the hours following the pack, there is an increased absorption of oxygen, determined by the increased consumption of stored oxygen during the pack, the fundamental condition of anæmia tends to be modified.

This oxygen could only pass into the blood combined with the hæmoglobine. If the demand of the tissues for oxygen exceeds the amount which can be carried by the existing amount of hæmoglobine, a tendency is initiated toward the formation of more hæmoglobine, provided the remaining elements of its composition, iron and albumen, are simultaneously furnished in sufficient quantity. Obscure as must at present be our conception of the operation of this, as of any other physiological "tendency," it is at least as clear as that which we can frame of the tendency to the reconstruction of entire blood corpuscles, which is to be initiated by the simple process of introducing more iron into the blood. Yet this tendency has long been regarded as extremely comprehensible, and Hayem's recent essays reaffirm this idea without any better explanation of it:

"Iron is an agent which constantly solicits the blood corpuscles to charge themselves with hæmoglobine."

"The ferruginous medication is therefore one of the most rational in therapeutics." *

Both these remarks are undoubtedly true. Yet not a very wide clinical experience is required to show that this same medication, employed alone, frequently fails. This, not because it is not rational, but because it is not sufficient.

The administration of iron in anæmia encounters the following difficulties:

1. The frequent occurrence in anæmic persons of gastro-

* Des caractères du sang dans les anèmies, 1876.

intestinal hyperæmia, which interferes with the absorption of iron, and is itself easily aggravated by its presence.

2. Ordinary food contains enough iron for the maintenance of the blood in health, but in anæmia this ceases to be appropriated. Whatever hindrance exists to such appropriation, must be overcome before the excess, given therapeutically, can be taken up.

3. The construction of the blood corpuscles demands oxygen and albumen as imperatively as iron. To judge from the researches, now classical, of Quevenne, Miahle and others, iron is mainly absorbed in combination with peptone, and in proportion as it produces its primary effect of increasing the secretion of gastric juice and also the amount of peptone dissolved in it. But this effect is not unfrequently prevented, and cannot be produced unless other therapeutic agencies are made to coöperate with the iron.

The preceding pages have sufficiently indicated the various ways in which the cold pack may be demonstrated or expected to aid in overcoming these difficulties. It would be superfluous and outside of our subject to attempt to show the advantage to be derived from the iron, when the various hindrances to its effectiveness shall have been removed. One remark, however, may be permitted.

Although in normal blood the iron exists exclusively in the hæmoglobine of the corpuscles, it seems to be possible, under some circumstances, to introduce more iron than could possibly be so combined. Thus, with the iron treatment of diphtheria, when five minims of tincture of iron are given every 15 or 30 minutes, although it be admitted that some of this escapes absorption, yet the unquestionable efficacy of this particular treatment would not, as it seems to us, be explained sufficiently by local action on the pharynx, and implies that a considerable portion of the iron ingested passes into the blood and, necessarily, into its serum.

It was this medication that suggested to us the possibility of introducing a great deal of iron into the blood by giving soluble preparations of it in minute doses frequently repeated, *e. g.*, a grain of the tartrate of iron and potassa every hour, accompanied by at least a few mouthfuls of food. We ask ourselves whether the iron, which possesses the property, common to the inorganic substances of the economy, of increasing the diffusibility of albuminoids, may not be useful on this account, and apart from its relations with hæmoglobine. In that case it is conceivable that an amount of iron could be utilized considerably in excess of what could be taken up by the blood corpuscles, or even made available in their regeneration.

Among the many complex processes affecting albuminoid substances, which are so largely carried on in the liver, the formation of blood corpuscles, at least in part, must be probably reckoned. Malassez, as the result of comparative measurements of the hæmoglobine of the blood before and after its passage through the spleen, has revived the old opinion of Hewson that the spleen also concurs in the production of the red corpuscles.* In either case, the increased circulation through these great glands, which we have seen to have such an effect on the production of urea, should facilitate the hæmapoietic action also.†

To sum up: Anæmia is a morbid state, characterized by an inability on the part of the tissues to condense oxygen and to store albumen in sufficient quantity. The inability is frequently congenital, or acquired in early childhood.‡ As a first consequence, the reserve material required in the elaboration of force is everywhere deficient. As a second

* Soc. de Biol., 1876.

† *Stasis* in liver or spleen is attended by destruction of corpuscles.

‡ Leichtenstern (loc. cit., p. 1), has shown that the physiological minimum of hæmoglobine in the blood is found in a period of life between the age of six months and five years. Many influences are imminent, capable of prolonging this physiological anæmia into adolescence.

consequence, this elaboration of force is deficient,—there is a generalized functional debility.

The atrophy of the blood corpuscles, or of their functionally active portion, hæmoglobine, is not an isolated lesion, and alone characteristic of anæmia. It must rather be considered as the most easily demonstrable illustration of a disorder common to all the organized albuminoids of the body.*

The cold pack meets the following indications for the treatment of anæmia thus understood:

1. In the first moments of application it produces the same stimulation of the peripheric nerves as may be caused by any application of cold,—shower-bath, douche, plunge-bath, etc.

2. It impresses upon the mass of circulating blood a profound movement of oscillation, first from without inward, then the reverse. The effect is different in the two periods.

During the inward movement of the blood, the tension of the abdominal blood-vessels, which has at first been lowered through the agency of the depressor nerve, at first relaxed, becomes raised by the increased volume of blood driven to them, and circulating through the abdominal viscera, not with increased rapidity, but with increased force. As a consequence there is:

a. Increased metamorphosis of albuminoid substances in liver and spleen, resulting finally in greater production of urea. When iron is absorbed with the albumen, there seems to be initiated in these same glands more abundant regeneration of red corpuscles.

b. Increased consumption of stored or latent oxygen in the series of oxidations culminating in urea. Hence, during the period following the pack, probably increased ab-

* These two statements are deductions obtained by comparing the clinical phenomena of anæmia with the results of various physiological researches. It would be very desirable to test their validity as far as it might be done by means of respiration researches with Pettenkofer's apparatus.

sorption of oxygen, coinciding with diminished oxidations. The latter are indicated by diminished production of urea. (Of carbonic acid also ?)

c. Possibly increased movement of assimilation of now decomposed albumen (and other food), coinciding with the movement of increased decomposition, affecting that portion of circulating albumen which has originated the urea. Both movements immediately dependent on an increased force of elementary, intervascular circulation.

d. Probable assimilation of the non-nitrogenous portion of the decomposed albumen.*

e. Increased elimination of water from the kidneys, and hence, aspiration of excess of water from anæmic tissues.

f. During this elementary outstreaming of water, facilitated washing away of acid fatigue-products from nerves and muscles.

This latter (calculated) effect, to be attributed partly to the second half of the movement of oscillation of the blood mass. During this secondary movement from within outward, we have :

A. Diminution of passive hyperæmia in the alimentary mucous membrane.

B. Increased nutritive absorption, partly in consequence of allayed hyperæmia, partly as the direct expression of a movement of fluids outward from the alimentary canal.

C. Afflux of blood to muscles, enabling them to increase their store of contractile material, and thus become more capable of exercise.

D. In this afflux, and on account of thermic irritation of the peripheric nerves, increased production of heat. From the coincident immobility of the body, and the arrest of radiation, a certain proportion of this increment saved. (The increment of urea is probably derived, in part, from

* This is to be inferred, if the elimination of CO_2 should be found unchanged or diminished during the period of increased production of urea.

increased chemical changes of circulating albumen in the muscles, during the production of heat.)

E. In the production of heat in response to a physiological stimulus, the nervous system, through the portion involved in the reflex mechanism, is especially stimulated, and the stimulus is immediately followed by special provisions for repose.

F. During the afflux of blood to the periphery, blood is drawn from the nerve centres, which are thus placed in a condition analogous to sleep,—a condition favorable to repose and to nutritive assimilation. The establishment of an equilibrium of temperature is followed by a cessation of chemical activity in the muscles, and necessarily by sedation of the nerves. These effects are of especial symptomatic importance in irritable anæmias.

3. During the pack the radial pulse is slackened, and its tension lowered. We may infer increased facilities for nutrition in tissue-elements hitherto irritated rather than nourished by a blood-stream imperfect in quantity and too rapid in duration.

Massage intensifies and prolongs some of the effects of the pack, when this has previously been administered.

Given alone, it is much less effectual than the pack, because its influence is less complete, and especially because it is less certain to determine blood to anæmic muscles.

In cases of "neurasthenia," or of hysteria, the cold pack is only beneficial in proportion to the coexisting anæmia. If this is not marked in proportion to the neurotic element, the pack may be useless or even injurious.*

The cold pack is decidedly dangerous, if administered too near to periods of abdominal hyperæmia, whether physiological, as digestion and menstruation, or pathological, as in lurking peritonitis.

* In several cases of hysteria, in which the hæmoglobine was measured by Quinquaud (*Recherches d'Hématologie Clinique*, Paris, 1880), the quantity was found to be normal.

Hydropathy

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Fowler & Wells

~~Water cure~~

~~Hygienic~~